DEPARTMENT OF TECHNOLOGY
BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 5 NO. 53 MAY 1959

VOLUME 5 NUMBER FIFTY-THREE MAY 1959

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* COVENT GARDEN 1871 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SEVEN SHILLINGS ANNUAL SUBSCRIPTION TWO POUNDS

Contents

273 **Transistor convention**

274 **A responsibility**

275 **The vacuum switch and its application to 'power' switching**
by M. P. REECE, B.SC.(ENG.), ASSOCIATE MEMBER

279 **Special General Meeting**

280 **Electrical engineers and electronics**
by R. W. PALMER, MEMBER

284 **The Summer Meeting of The Institution**

285 **Electric power in Europe**

286 **The 1959 Annual Dinner of The Institution**

294 **Programme of the International convention on Transistors and associated semiconductor devices**

300 **A review of the *Proceedings*, Parts A and B**
(*details are given in the adjoining column*)

315 **Correspondence**

316 **Obituary**

318 **Technical publications**

319 **Papers and monographs published individually this month**
(*details are given in the adjoining column*)

320 **Some recent books**

328 **Elections and transfers**

329 **Library accessions**

331 **Announcements to members**

333 **Contents of the current issues of the *Proceedings***

333 **Forthcoming events at Savoy Place**

334 **Bulletin of the Sections**

340 **News from the Centres**

343 **News from abroad**

BACK COVER **Index of advertisers**

300 **A review of the *Proceedings*, Parts A and B**

Geoelectric surveys	Prof. L. S. Palmer
Influence of consumers' load/consumption characteristics on metering practice	L. B. S. Golds
Discrimination between h.r.c. fuses	E. Jacks
Automatic graph plotter	M. P. Atkinson, W. T. Bane and D. L. A. Barber
High-current-density thermionic emitters	A. H. W. Beck
Standardization and simplification of switchgear	M. J. L. Willison
H.V. circuit-breakers with insulated-steel-plate arc chutes	F. S. Fay, J. A. Thomas, D. Legg and J. S. Morton
Accurate measurement of g_m	M. R. Child and D. J. Sargent
Perturbation method for circular waveguides containing ferrites	P. J. B. Clarricoats
Directive aerials in complex u.h.f. fields	J. A. Saxton and B. N. Harden
Transistors and associated semiconductor devices	R. G. Hibberd
Measurements from U.S.S.R. earth satellites	W. C. Bain and E. D. R. Shearman
Hemi-isotropic radiators for the S- or X-band	E. G. A. Goodall
Integrally constructed waveguide assemblies	G. Craven and V. H. Knight
Current gain of plane-alloy-junction transistors	F. J. Hyde
Current gain of drift transistors	F. J. Hyde
H.F. power gain of drift transistors	F. J. Hyde
Phase measurements through tapered junctions	L. Lewin

319 **Papers and monographs published individually this month**

PAPERS

Engineering education in Germany	D. B. Welbourn, Prof. D. B. Spalding and G. L. Ashdown
Problems of engineering education	Professors H. G. Kayser, K. Luerenbaum, K. Müller, R. Sauer, H. Stefaniak and R. Wille

MONOGRAPHS

Electromagnetic energy transfer	P. Hammond
Gain of travelling-wave ferromagnetic amplifiers	P. J. B. Clarricoats

Summer Meeting Abbey

FOUNTAINS ABBEY, illustrated on the front cover, was, at the time of its suppression, one of the most magnificent and important monasteries in Britain. Situated in the Vale of Fountains, a narrow glen watered by the Skell, it was built by monks from St. Mary's Abbey at York. They followed the Cistercian rule and were the pioneers of the wool and sheep industries in Yorkshire. They benefited agriculture, reclaimed waste spaces and looked after the poor. At the Dissolution, the Abbey was despoiled and the lands and the edifice sold to Sir Richard Gresham, father of the founder of the Royal Exchange. The property passed from his representatives into the hands of Sir Stephen Proctor, who in 1611 pulled down the infirmary and with the materials built Fountains Hall, to the west of the Abbey. On Tuesday, 16th June 1959, participants in the Summer Meeting of The Institution in the North Midland Centre will have the opportunity of visiting the Abbey on a tour of the district via Otley, Blubberhouses and Ripon. The photograph is published by arrangement with *The Yorkshire Post*. A note about the Summer Meeting appears on p. 284

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

© 1959: The Institution of Electrical Engineers

Advertising Office TERMINAL HOUSE, GROSVENOR GARDENS, LONDON S.W.1 *Telephone* SLOANE 7266 *Telegrams* INDULICITY, SOWEST, LONDON

The Institution is not, as a body, responsible for the opinions expressed in the *Journal*, unless it is stated that an article or a letter officially represents the Council's views

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 5 NUMBER 53 MAY 1959

TRANSISTOR CONVENTION

It is a matter of history that the phenomenon of electronic emission found one of its first applications in valves performing various functions in wireless transmitters and receivers, so that radio, as it came to be called, gave an initial impetus to the development of electronic devices which in due course were used in other fields now collectively referred to as electronics. It is a natural consequence of this origin that, within The Institution, the science and many of the applications of electronic phenomena should be dealt with by the Section that began as the Wireless Section. Thus it was the Radio and Telecommunication Section, as it had by then become, that a year ago sponsored an International convention on Microwave valves.

Many of the devices there described, such as the travelling-wave tube and the backward-wave oscillator, have stimulated new and far-reaching advances in the technique of communication at very high frequencies, but by this time the field of electronics had assumed a major importance in its own right which was recently acknowledged by yet another change in the title of the Section to the Electronics and Communications Section.

This change is particularly appropriate in view of the International convention on Transistors and associated semiconductor devices which the Section, with the approval of the Council of The Institution, is holding at Earls Court from the 21st to 27th May 1959, for within ten years of its discovery the transistor has become a major factor in electronic research and in scientific and industrial application. Its development has taken place side by side with that of microwave valves and, as in the case of thermionic emission and indeed of electromagnetic waves, it had its origin in pure research. The fundamental nature of the work of Prof. J. Bardeen, Dr. W. M. Brattain and Dr. W. B. Shockley was acknowledged by the joint award of the Nobel Prize for their invention of the transistor arising from the study of the surface properties of semiconductors.

The history of the development of the transistor has been a fascinating story of the mastery of difficult techniques for the production of germanium crystals of extremely high purity and the introduction of controlled but minute amounts of specific impurities, such as indium and arsenic, on which the successful operation of the device depends. The reduction of these techniques to a production process has become one of the romances of industrial achievement, making possible the employment of the transistor over an ever increasing range of practical applications.

As with many other basic phenomena, although a fundamental understanding demands a deep knowledge of modern atomic theory, the physical properties of semiconductors can be explained in comparatively simple terms. Thus it is possible, by learning to think in terms of 'holes', *p–n* and *n–p* junctions and the like and by becoming familiar with the characteristics defining the performance of transistors, to acquire a working knowledge of the way they can be used in electronics and communications.

In every branch of electrical technology there are now engineers, most of whom would not claim to be experts in atomic physics, who nevertheless are advancing our knowledge of the remarkable possibilities of the transistor as an electrical component. By so doing they are helping to bring about one of the major technological revolutions of our time.

To the general public the transistor is probably synonymous with the miniaturization met with in radio sets and hearing aids. This aspect of its use is indeed paramount in many specialized and highly advanced applications, as in electronic computers, guided missiles and space rockets.

The transistor must not, however, be thought of merely as performing more conveniently or economically a task that could be fulfilled by a conventional valve; nor does it follow that it will ultimately replace the valve altogether, bearing in mind for instance the requirements of large-power and very-high-frequency operation. Its behaviour as a current rather than a voltage device and the facility with which it can be incorporated into electrical circuits give it a function in its own right that opens up many new applications of immense significance in the electronic field.

The importance attached by The Institution, through the Electronics and Communications Section, to the development and application of the transistor is shown in the organizing of the forthcoming convention. This move has been amply justified by the great interest and support it has evoked, judging by the number who have signified their desire to attend and by the volume of papers submitted for the technical sessions. Quite apart from the present building operations at Savoy Place, it was in anticipation of about 2000 participants that it was decided to hold the convention elsewhere.

It may be recalled that one of the methods of fulfilling the objects of The Institution as set out in its Charter is to facilitate the exchange of information and ideas on electrical science and engineering by the promotion not only of meetings but also of exhibitions. The moving of the convention away from the Institution building has enabled the holding of a full-scale exhibition, marking the first occasion on which the leading laboratories and manufacturers of the world will be showing the latest technical developments associated with the subject of an Institution convention.

The sessions will cover the whole field, from basic theory and materials, characteristics and measurements to design and manufacture and industrial applications, and of the total of 23, 11 will be of a specialist nature. There will be several social events, including two convention lunches, a cocktail party, and a convention dinner at the Connaught Rooms on the final evening; while a programme including visits to places of interest in and around London will be arranged for the ladies accompanying delegates to the convention. As the convention proceeds, it will become manifest that this country has been well to the fore in the world-wide advances in technology based on the discovery of the transistor and that it is appropriate for it to be the venue of such an international gathering. The sessional programme is on p. 294.

The truly international character of the convention is shown by the large number of delegates expected and of papers received from oversea and by the fact that the introductory lectures are to be given by the Nobel Prize-winners from the United States. In gratefully acknowledging their acceptance of the invitation extended to them, it is a pleasure to record that the importance of the occasion will be matched by the presence of the Rt. Hon. The Viscount Hailsham, Lord President of the Council, who has kindly consented to open the convention.

A RESPONSIBILITY

In settling the most suitable machinery for the government of so large a body as The Institution, the problems that arise reflect in miniature those of the central government of our country; and in seeking the best possible method much guidance can be obtained from the concentrated experience of the centuries which goes to make up the British system.

In both cases, the kernel of the problem is how to achieve a balanced and effective representation of all sections and interests, while at the same time providing at the centre a responsive and responsible executive organization. The problem has no final and complete solution: improvement must constantly be sought for and pursued, and evolution is the companion of growth and progress. A living organism cannot stand still; it either grows or declines. Under our Royal Charter, 'the government and control of The Institution and its affairs shall be vested in the Council, subject to these Presents (i.e. the Charter) and to the Bye-laws of The Institution'. As the science of electrical technology develops, corresponding changes are required in the instruments of The Institution's government—its Bye-laws, and, less frequently, its Charter.

The Council are alive to their responsibilities in this regard, and, after a careful review, from time to time put forward their recommendations for changes. One such set of recommendations, concerning the Bye-laws, came before the Corporate members entitled to vote, at a Special General Meeting of Corporate members only, held on the 9th April 1959. In deciding on their proposals, the Council had the advice of their Finance, General Purposes, Education and Training and Membership Committees; and they had the benefit of considering suggestions sent in from Local Centres, or communicated by individual members, or made in the discussions at an Annual General Meeting, or put forward by the Committee of a specialized Section.

Members of The Institution can take pride in the democratic character of the Council, who include among their number not only the President, the five Vice-Presidents and the Honorary Treasurer, but also, among the elected members, one from the class of Companions, one from the class of Associates, and four from the class of Associate Members, as well as 14 from the class of Members. The Chairman and immediate Past-Chairmen of all our Local Centres, and the corresponding Officers of the four specialized Sections, serve on the Council in an *ex officio* capacity.

Our members can also feel proud of the democratic nature of the process by which Bye-law changes, or, indeed, changes in the Charter itself, are discussed and approved. All such changes must, as has been said, come before a Special General Meeting of Corporate members for approval—an electorate of 17073 were, on the most recent occasion, entitled to receive, and did receive, the calling notices for the meeting. It is clear that physical difficulties would arise if they all attended in person. This situation has been foreseen and has been met by a procedure whereby absent members can vote by proxy.

The essence of this procedure is that a member not able to be present empowers a member who can, to cast the absent member's vote in addition to his own, should the question before the meeting become the subject of a poll. The giver of a proxy can, if he wishes, select as his proxy holder a member of like views to his own, and on whose judgment he relies, and allow him to cast his vote as the proxy holder sees fit, after the proxy holder has heard and perhaps participated in the discussion at the meeting and has listened to the arguments.

It is in this last and most important particular that the proxy procedure offers advantages over the alternative of a postal referendum which some other constitutions provide. In these, the voter must cast his 'yea' or 'nay' on the written information which may be before him, his own predilections and, it may be, his exchanges of view with his own circle of acquaintance, without any opportunity of taking account of the interchange of argument and opinions which a Special General Meeting provides. This same disadvantage applies to the 'tied' proxy, whereby its holder is instructed by the giver, in advance, to vote in a certain direction, irrespective of the influence of the give and take of debate on the issues—thus stultifying that free discussion which is so fundamental a feature of effective democratic government.

But, for these safeguards to work, they must be used. Of the 17000 members entitled to participate in the meeting on the 9th April, less than 100 attended, and less than 200 sent in their proxies. An opportunity to do better will occur shortly, when the proposals for increases in Entrance Fees and Annual Subscriptions come again before our Corporate members with the fuller particulars which the President undertook to provide.

The vacuum switch and its application to 'power' switching

621.316.57.064.26

This article describes the present state of the vacuum switch and its potentialities for alternating-current 'power' switching. It has been found with the vacuum switch, as in the past with other switches, that analysis of the phenomena at current zero requires a thorough understanding of the steady arcing before current zero. The author therefore discusses at some length the steady-arcing processes in a vacuum. Mr. Reece is with the British Electrical and Allied Industries Research Association.

M. P. REECE, B.SC.(ENG.), ASSOCIATE MEMBER

THE vacuum switch originated early in the history of electrical engineering. Rittenhouse[1] states that the earliest patent was filed in 1893, and this may well have resulted from the enunciation of Paschen's law (1889).

Up to the early 1920's vacuum switches were used, if at all, for very-low-power switching, but from 1923 to 1926 Sorensen and Mendelhall[2], at the California Institute of Technology, conducted a series of experiments in which they succeeded in interrupting an alternating current of 900amp at 40kV. The fact that these developments were not taken further was probably due to technical difficulties, such as the degassing of contact materials.

Small vacuum switches operated magnetically or thermally have long been used for the control of small resistive loads, particularly in applications where their hermetic sealing and lack of external moving parts are advantageous. These switches have, in general, handled only a few amperes at some hundreds of volts and have not been widely used—probably for economic reasons.

In the 1930's several manufacturers in Britain and America reinvestigated the vacuum switch, but for various reasons, including its tendency to 'chop' small inductive currents with the production of very large overvoltages, the 'power' vacuum switch did not make significant progress.

In recent years an American company has been making vacuum switches on a commercial scale, largely for high-voltage low-current applications, e.g. h.t. supplies to radio and radar transmitters. It is this type of switch which was used in the line-switching and load-switching experiments described by Jennings, Schwager and Ross[3] and by Rittenhouse,[1] in which the 80amp charging current of 150 miles of 230kV line and currents of 800amp at 18kV at low lagging power factors have been interrupted successfully, the latter repeatedly. Recent American work has been described by Ross.[4]

General properties of the steady-state vacuum arc

The properties of an electric arc in a vacuum are very different from those of other arcs. The expression 'vacuum arc' is, strictly speaking, a contradiction in terms because the essence of an arc, as opposed to a purely electronic discharge, is the presence of positive ions which neutralize the electronic space charge, allowing large currents to flow at low voltage gradients.

In the high-pressure arc, and to a very large extent in the low-pressure arc, the atoms which become ionized are supplied by the ambient gas or vapour. The vacuum arc, on the other hand, is one in a region in which the ambient gas pressure is so low that substantially all the positive ions are derived from metal atoms ejected from the cathode spot. These atoms themselves constitute a local atmosphere, having a vapour density very much greater than the ambient.

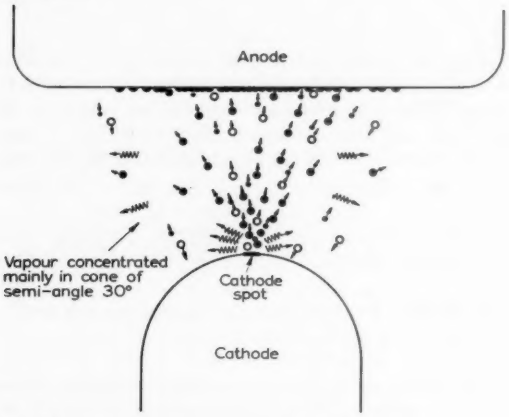
Two significant results follow from this: first, a vacuum arc will only burn with a low voltage if there is a 'line of sight' path between cathode and anode; and secondly, when a vacuum arc is extinguished the local pressure falls to the ambient value as metal atoms condense on adjacent cold surfaces.

There is no definite ambient pressure at which an arc can be considered to be a vacuum one, but it should be such that the mean free path of the residual gas molecules is large compared with the longest discharge path within the arc space. At atmospheric pressure the mean free path of most gases is about 10^{-5}cm; and since, in a vessel having a maximum internal dimension of 1cm, the mean free path should not be less than 10cm, the vacuum must be better than 10^{-3}mm Hg before a discharge can be considered a vacuum arc. In most of the published work on vacuum arcs a pressure of 10^{-4}mm Hg—giving a mean free path of about 1m—has been considered as satisfactory.

At the electrodes, current flows between the discharge and the metal. Electrons from the discharge fall into the anode, giving up their kinetic energy and heat of condensation and heating the anode in the process. Neutral metal atoms also condense on the anode and give up

their kinetic energy, covering it with a film of material from the cathode.

Electrons and metal vapour are emitted from the cathode spots, and light is emitted from those portions of the discharge very close to the spots. The ratio of the number of electrons to the number of metal atoms liberated varies according to the material and form of the cathode, but a representative figure is ten electrons per atom.



1 *Diagrammatic representation of vacuum arc*

- Metal condensed on anode
- Ionized metal vapour
- Metal vapour
- Electrons
- Photons

Arrows indicate the direction of motion of the particles

The vapour is emitted from the region of the cathode spot at velocities of 10^5–10^6 cm/s, depending on the cathode material. The current density at the cathode spot depends on the cathode material but is probably of the order of 10^6 amp/cm^2 on copper. Positive ions in the plasma cone are carried to the anode by the blast of metal vapour, but those scattered out of the cone drift to the cathode

The general operation of the vacuum arc is thus as illustrated diagrammatically in Fig. 1: one or more very small and hot cathode spots eject electrons, photons and metal vapour. The electrons and metal atoms, travelling with high velocities, spread out in a cone of semi-angle about 30°, which forms the discharge. A proportion of the metal atoms are ionized, possibly during the process of ejection, and the charge on these is sufficient to neutralize the electronic space charge.

As the jet spreads, the vapour density and current density fall, so that the arc in some respects resembles a high-pressure arc at points very close to the cathode spot and, as the particles spread out, rapidly becomes more akin to a low-pressure arc, very diffuse and less luminous. Ions, electrons and neutral atoms diffuse out of the discharge, the ions recombining at the walls and forming, together with the neutral atoms, a film of metal on adjacent cold surfaces. The continuous transfer of material in the vapour phase from cathode to anode is a feature of the vacuum arc which is not paralleled in any other type of arc.

Phenomena in the discharge and at the anode

The vacuum arc, unlike the high-pressure arc, has no definite arc column. In the region of the cathode spot, the luminosity and the current and particle densities are high. The current density at the cathode spot itself is probably of the order of 10^5–10^6 amp/cm^2, depending on the cathode metal, and the vapour density close to the spot is probably equivalent to a pressure of several atmospheres.

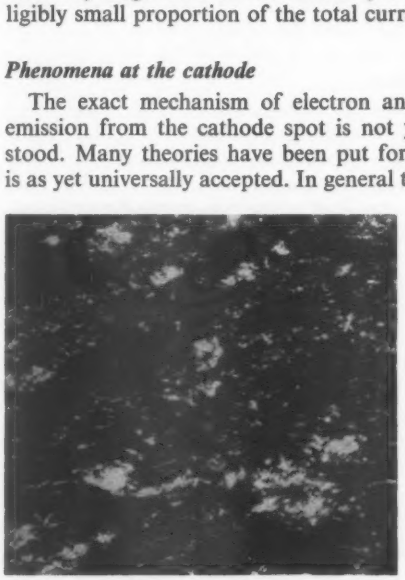
Once away from the immediate vicinity of the cathode spot, collisions between particles become relatively rare, and thus volume recombination, with its attendant light output, is very slight. Because collisions are rare, the voltage gradient is very small. It is rather difficult to measure, but, provided that the geometry of the electrodes is correct, it is less than 0·05 volt/cm. An electron current flows to the anode, which the electrons heat by virtue of their kinetic and condensation energies. Heat is also supplied to the anode by the rapidly moving neutral atoms.

In discharges at somewhat higher ambient pressures, e.g. in the mercury-arc rectifier, the anode may be surrounded by a positive or negative sheath, depending on its area and the current flowing to it. In the vacuum arc, a negative sheath will surround the anode in certain circumstances, but it is unlikely that a positive sheath can ever be formed. To avoid the formation of a negative sheath and consequent high voltage drop, the anode must subtend a large solid angle at the cathode, so that most of the electrons emitted from the cathode spots are intercepted by the anode.

A positive-ion current flows to those areas of the cathode near the cathode spot, but because of the relatively large mass of the ions they carry only a negligibly small proportion of the total current.

Phenomena at the cathode

The exact mechanism of electron and metal-vapour emission from the cathode spot is not yet fully understood. Many theories have been put forward, but none is as yet universally accepted. In general the cathode spot



2 *Photomicrograph* (×100) *of copper cathode, showing microscopic melting*

on solid metals in a vacuum is very similar to that on mercury, moving continuously over the surface with considerable speed, sometimes at 50 m/s.

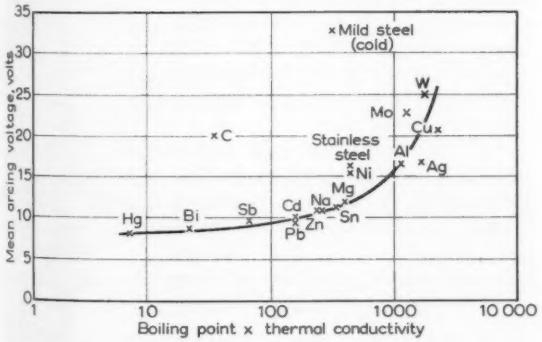
The track of the spot always exhibits microscopic melting, a photomicrograph of which is shown in Fig. 2. If the arcing has continued long enough to cover most of the surface, this gives it a 'velvety' appearance, unless the metal has become so hot that gross melting has occurred, when, of course, the surface is smooth and shiny. The area of any individually melted area in a region of microscopic melting is seldom greater than 10^{-5} cm^2, and in a series of experiments made in controlled conditions the tracks of cathode spots as small as 10^{-8} cm^2 have been observed.

Metal vapour is ejected from the cathode spots at velocities higher than can reasonably be accounted for on a basis of temperature alone, i.e. 10^5–10^6 cm/s. It seems likely that the acceleration of the metal vapour occurs just in front of the spot, in the region where the discharge is subjected to a magnetic 'pinch' before it spreads out into a cone. For copper, the mean velocity (in terms of kinetic energy) of the ejected vapour is about 33 eV, i.e. greater than the total arc drop; since only about one atom is emitted per ten electrons, no energetic difficulties exist, but the exact mechanism by which the energy is transferred to the metal vapour is not yet definitely established.

One interesting result is that, if positive ions are formed in the pinch, some of them probably travel to the anode, against the field, owing to their inertia. Since only about one ion is formed per 100 electrons emitted, this unusual behaviour would not be unreasonable.

Effect of cathode material

The voltage drop in a vacuum arc is very largely concentrated at the cathode spot, increases very slightly as the current increases, and depends on the cathode material. It is not yet possible to relate the voltages directly to physical properties of the materials, but it is apparent that in general they are dependent on the thermal properties. Fig. 3 shows the relationship between arcing voltage and thermal properties for a number of materials. Many of the points fall on a smooth curve, but there are exceptions, such as iron and carbon.



3 *Empirical relationship between arcing voltage in a vacuum and physical properties for some common metals*

Although the voltage drop in a vacuum arc occurs at or near the cathode spot, some portion of it is expended in accelerating electrons, which then travel across the gap without collision and dissipate their energy at the anode. Thus, in a copper vacuum arc, of 20·5 volts dropped at the cathode only 8 volts serve to heat the cathode, the other 12·5 volts heating the anode.

High-frequency components

The arcing voltage of a relatively low-current arc contains many high-frequency components, although the mean value is very consistent for a given cathode material. It seems likely that the h.f. components are related to the rapid motion of the cathode spot.

Associated with each cathode metal in a d.c. vacuum arc is a minimum stable current depending on the circuit parameters. For materials like tungsten, with high arcing voltages, the minimum stable current is large—about 50 amp d.c. in one particular circuit. As the arcing voltage decreases from metal to metal, so does the minimum stable current, until, for cadmium in the same circuit, it is less than 2 amp. At currents lower than these the arc burns for a short time and then goes out; the smaller the current, the shorter the burning time.

4 *A high-speed photograph of a 1000 amp copper vacuum arc*

The minimum stable current has been shown to be the controlling influence in determining the 'chopped' currents and resulting overvoltages when small magnetizing currents are interrupted in a vacuum. For instance, in a given circuit, the minimum stable current with a copper cathode is over ten times that with a bismuth cathode, so that copper contacts interrupting magnetizing currents can give rise to prospective overvoltages ten times greater than with bismuth contacts. It has been found, as has also been reported by Ross,[4] that a reduction in overvoltages when interrupting small inductive currents may be obtained by reducing the velocity of contact separation.

Coexistence of cathode spots

The constriction resistance of the metal close to each spot forms, in effect, a self-contained series resistor to each cathode spot, giving rise to a slightly positive voltage/current characteristic. For this reason it is possible for several cathode spots to burn in parallel. Thus, on copper contacts a 5000 amp arc forms about 50 separate highly mobile cathode spots, each carrying about 100 amp.

Fig. 4 shows a number of separate coexistent cathode spots, the total instantaneous current being 1000 amp.

High-speed cinéfilms show that the separated spots tend to repel each other and run outwards to the edge of the negative contact, a manifestation of retrograde motion of cathode spots at low pressure, wherein spots move against the normal electrodynamic force acting on a current-carrying conductor in a magnetic field.

Preferential arcing

If a cathode is made of two different metals, both accessible to the cathode spots, it is found that the spots usually tend to remain on the material having the lower cathode voltage drop. For example, when an arc was initiated on a steel cathode (33 volts) plated with cadmium (10 volts) the cathode spot ran all over the cathode, emitting a green light, with an average voltage of 10.

When the whole of the cadmium film had been evaporated from the surface, the spots became blue, and the arcing voltage rose to 33 volts. Another example of this preferential arcing was shown by the evaporation of the silver solder which had been used to retain a tungsten button in a depression in the surface of a copper contact.

The energy to maintain the cathode spot is supplied mainly from three sources:

Positive-ion bombardment of the cathode spot
Heat transfer from the concentrated portion of the arc immediately in front of the cathode spot
Joule heating of the metal immediately behind the cathode spot.

The relative importance of these sources is not yet known, but recent experiments have shown that, at least in certain conditions, the last can be very important.

Various experimenters have measured the rate of metal evaporation at the cathode spot in a vacuum. Table 1 shows a summary of the results, which are reasonably consistent. Measurements have not yet been made at very high currents; but because of the splitting of cathode spots, the quantity of metal evaporated per coulomb should not vary greatly with current.

The 'current zero' period

The vacuum switch will interrupt only very small direct currents, i.e. those below the minimum stable arcing current. Its ability to interrupt very much larger alternating currents depends ultimately on preventing the formation of cathode spots on the negative contact after current zero. These spots may be initiated either by too high a post-zero power density at the contacts or by the presence on the contacts of patches having low work functions.

At current zero there is a certain amount of residual metal vapour and gas in the inter-contact gap, some of which is ionized. Under the influence of the restriking voltage, the ions and electrons move to the negative and positive contacts respectively, giving rise to a post-zero current of very short duration. This bombardment of the contacts constitutes a post-zero power at the contact surfaces. With too large a post-zero power density or too low a work function or boiling-point, a

Table 1. Rate of evaporation of metals at vacuum-arc cathodes

Cathode material	*Form of cathode*	*Current, amp*	*Evaporation rate, μg/coulomb*	*Electrons per atom*	*Source*
Copper	Block	15	87	7·6	Robertson*
Copper	Block	40	70	10	E.R.A.
Mercury	Drop	0·8	250	8·3	Tonks†
Cadmium	Very thin film	2	40	29	E.R.A.
Cadmium	Block	5	400	2·9	E.R.A.
Magnesium	Block	5	40	6·3	E.R.A.
Lead	Block	30	1100	2	E.R.A.
Zinc	Block	30	230	3	E.R.A.
Silver	Block	30	35	32	E.R.A.
Steel	Block	up to 200	50	11·7	Khalifa‡

* Robertson, R. M., *Physical Review*, 1938, 53, p. 578
† Tonks, L., *ibid.*, 1938, 54, p. 634
‡ Khalifa, M., *Canadian Journal of Technology*, 1956, 34, p. 304

cathode spot will be formed, the arc will reignite, and the voltage will drop to the arcing voltage of the contact material.

The work function and boiling-point of the contacts depend on the material used and its preparation. The post-zero power density is a function of the vapour density, the number of ion pairs between the contacts and the rate of rise of restriking voltage. Enough is now known of the arcing processes in a vacuum to enable this vapour density and its rate of fall to be computed; by correct design it can be greatly reduced, resulting in an increased interrupting ability.

Potential applications of vacuum switches

There seem to be, broadly speaking, three main fields of application for the 'power' vacuum switch. These are load switching, contactor-type duties and circuit-breaking. The first application is exemplified by the load-breaking switch, used particularly in the North American supply networks for breaking load currents and line-charging currents. Vacuum switches have already been used for these purposes in the United States.

The switches, originally developed for low-power applications, successfully interrupt load and capacitance currents of hundreds of amperes at system voltages of 138 and 230 kV. A number of vacuum switches in series are used for these high voltages, usually four at 138 kV. Since they are not designed to carry large currents, a parallel isolator blade is usually provided.

Fig. 5 shows one such switch unit. The vacuum switch is particularly suited to capacitor switching, because a very small contact separation gives a very high electric strength, which prevents restriking and consequent stepwise voltage

5 *Single unit of high-voltage vacuum switch (American)*
One-quarter full size

build-up. Fig. 6 shows a somewhat smaller experimental switch of British design.

The vacuum switch has up to the present been unsuited to contactor duties because (a) most contactors operate at voltages of 6·6kV and below, and therefore the overvoltages commonly produced by vacuum switches when interrupting small magnetizing currents (tens of kilovolts) are too high, and (b) the rate of contact wear, although small, is by no means negligible, so that the life of a vacuum contactor would not be very much greater than that of an air-break contactor.

6 Experimental vacuum switch (British)
0·44 times full size

By utilizing the principle of 'preferential arcing', a contact can be made comprising two metals with different arcing voltages, so that only the material with the lower arcing voltage is eroded, the switch travel does not change with wear, and a long life—up to 10^8 operations—may be realized. Furthermore, this type of contact overcomes the overvoltage difficulty when interrupting small magnetizing currents.

It seems likely that the use of some such contact structure may enable the vacuum switch to compete, particularly at voltages above 440 volts, with the normal type of air-break contactor.

No vacuum switch has yet been constructed capable of interrupting the very large fault currents that a circuit-breaker must handle. For instance, for use as a circuit-breaker a vacuum switch would have to be capable of interrupting, say, 30kA at 33kV so that a series connection of several units would enable large circuit-breakers to be constructed.

The British Electrical and Allied Industries Research Association is actively pursuing these problems, and an experimental switch made there has interrupted 10kA (r.m.s.) at 3·8kV (r.m.s.). Although, at the moment, there appear to be no technical reasons why such vacuum circuit-breakers should not be made, very much more work will be necessary to overcome certain problems.

Summary

Several attempts have been made in the past to apply the vacuum switch to 'power' switching, as well as to the low-power applications it has had for a very long time. A new 'cycle of interest' in the vacuum switch has come round in recent years. In the United States vacuum switches have found certain load- and line-switching applications in power systems, and in this country the E.R.A. and electrical manufacturers are investigating its potentialities, with interesting results.

Acknowledgments

The author wishes to thank the Jennings Radio Manufacturing Corporation, San Jose, California, for Fig. 5 and the British Thomson-Houston Co. Ltd., Rugby, for Fig. 6.

References

1 RITTENHOUSE, J. W.: 'The role of the vacuum switch in power applications', *Electrical Engineering*, 1957, **76**, p. 202
2 SORENSEN, R. W., and MENDELHALL, H. E.: 'Vacuum switch experiments at the California Institute of Technology', *Transactions of the American I.E.E.*, 1926, **45**, p. 1102
3 JENNINGS, J. E., SCHWAGER, A. C., and ROSS, H. C.: 'Vacuum switches for power systems', *Electrical Engineering*, 1956, **75**, p. 350
4 ROSS, H. C.: 'Vacuum-switch properties for power-switching applications', *Transactions of the American I.E.E., Part 3*, April **1958**, No. 35, p. 104

Special General Meeting

A SPECIAL General Meeting of Corporate members of The Institution was held at Savoy Place on Thursday, 9th April 1959, when changes in the Bye-laws, which had been proposed by the Council and described in the notice circulated to Corporate members, were considered.

An amendment that the alterations which were proposed to Bye-law 26—Entrance Fees, and Bye-law 27—Annual Subscriptions, should be deleted was adopted by a small majority.

In the discussion, a number of speakers requested fuller details of the financial background and that sufficient opportunity should be given for these to be considered before a final decision on the proposed increases was reached.

In his replies, the President undertook that when proposals for increases in the Entrance Fees and Annual Subscriptions were submitted to a further Special General Meeting, supporting financial and other details, reference to which had been made in the discussion, would be circulated together with the notice convening the meeting.

Amendments were also adopted making textual changes representing drafting improvements in Bye-law 12 and deleting the words 'and that the work upon which he is engaged is conducive to this end' where they were proposed to be introduced in sub-paragraph (b) of Bye-law 15.

Subject to these amendments, the alterations proposed were adopted unanimously.

The meeting was attended by fewer than 100 Corporate members, and the President stated that 178 valid proxies had been received.

The agreed Bye-law amendments have been submitted for the allowance of the Privy Council; and, when their reply is received, details of the changes allowed and the customary condensed account of the Special General Meeting will be published in the *Journal*.

Electrical engineers and electronics

621.3:621.389

The word 'electronics' has many vague meanings, but a historical survey confirms that electronic principles are not the monopoly of the light-current engineer and that they are increasingly the concern of electrical engineers of all kinds. Thus, it is proposed that the term 'electronic engineering' should be avoided and replaced by more precise classifications such as electronic control, electronic rectification, electronic illumination and perhaps (one day) electronic generation. This outlook has a bearing on the subdivisions of the Proceedings of The Institution, which at present link electronics with communication and radio and tend to segregate it from power engineering.

This article is based on the Address given by the author as Chairman of the North Staffordshire Sub-Centre at Stone on the 10th October 1958.

R. W. PALMER, MEMBER

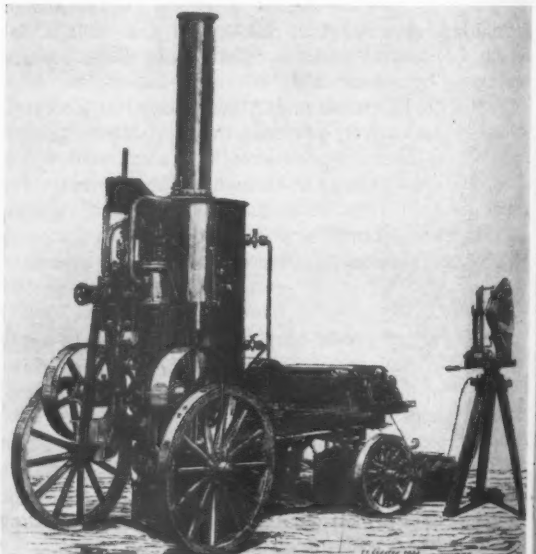
So much is being written and said about electronics that it may seem superfluous to refer to it again, yet it is the one modern technical development of universal interest to electrical engineers, whatever their specialized activities might happen to be. The popular definition of electronics is 'the use and manipulation of thermionic valves and similar components of the type in which electrons are freed from metals', and it is widely assumed that such techniques are exclusive to light-current engineering, notably telecommunication. But it is unfortunate that the terminology is so vague.

Is the word 'electronics' merely an abbreviation of 'electronic engineering', or does it refer to a science in its own right? Should the title be confined to the emission of electrons in a vacuum, or may it include phenomena in semiconductors and the passage of current through gases? Is electron-physics electronic or is it not? There are conflicting answers to such questions among engineers and scientists, but I include as 'electronic' in this article all the electrical principles arising from the discoveries of modern solid-state physics and nuclear physics.

If this can be accepted, the applications of electronics in many fields are interrelated, and we need to get a new sense of proportion between light-current and heavy-current engineering. It seemed to me that a glance at the past would help in this respect.

The birth of electrical engineering

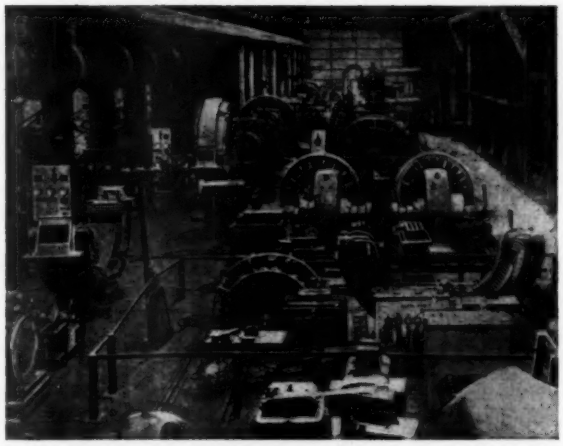
It is difficult to decide on a precise starting date, because one definition of 'engineering' is 'the design and construction of works of public utility', and who is to say at what point in time an experimental machine becomes useful to the public? Philosophical and scientific knowledge of electricity and magnetism has been slowly accumulating for thousands of years, but at the beginning



1 (above) *Metropolitan telegraphy gallery, London (1871)*

2 (right) *Arc lamp and generator driven by steam engine (1875)*

3 *Flat-multiple telephone exchange, Glasgow (1901)*



4 *Dynamo works at Stafford (1906)*

of the 19th century scientists demonstrated some electrical experiments that showed promise of practical utility, even using such items as Leyden jars, pith balls, electroscopes and frogs' legs.

The only kind of electricity that had been produced was in the form of static charges and surges, and yet the impelling urge of the engineer was already being demonstrated by field trials of a telegraphic system, using pulses of static electricity. It had no future; but then came an important new discovery—the production of a sustained current of electricity for the very first time. This was obtained chemically from the Voltaic battery and before 1810 had been used for researches in electrochemistry and even for the production of a light in the form of a feeble carbon arc.

Electrical engineering was about to begin, and the important contribution for which the world waited was Faraday's production of electricity by magnetic induction in 1831. The stage was now set. If any specific date is to be selected for the birth of electrical engineering I would choose 1837, when Wheatstone and Cooke took out the first patents for a practical 5-needle telegraph.

It is significant that in this year was born the 'Electrical Society of London', though it was destined to survive only six years before being overtaken by debts. Thereafter, the newly crowned Queen Victoria witnessed the speed and energy with which the electric telegraph was introduced. An electric public utility had really arrived.

The Victorian era (1850–1900)

For 50 years the telegraph monopolized the electrical world. It is true that a large self-excited dynamo dispensing with the need for permanent magnets was built in 1870, but the greatest handicap seemed to be the absence of good practical applications for the electric current even when we had got it. There were, indeed, a few rather crude arc lamps installed in some lighthouses; but it was a case of one dynamo to light one lamp (Fig. 2). Thus, we can appreciate why the origin of our Institution in 1871 was a 'Society of Telegraph Engineers.' There is little doubt that its meeting rooms were lit by gas.

Before the end of the century the situation began to change when the heavy-current engineers discovered an entirely new and inspiring job for electricity to do, namely the subdivided electric light, made possible in 1878 by the invention of the carbon-filament lamp. Its use was accompanied by an important change in electrical generation from the constant-current system (as previously used for arc lamps) to the constant-potential system that enabled as many filament lamps to be used in parallel as were required.

With this new public service to fulfil, it was not surprising that the name of our professional body was changed in 1880 to the 'Society of Telegraph-Engineers and Electricians', and again in 1888 to the present title.

While the telegraph system was being perfected and introduced on a large scale (Fig. 1), telephony was being started with single-wire galvanized-iron lines and the power engineers astonished the public with electric trams and railways. The technical advances in central power stations were so rapid that a 30 kV 3-phase system was operating in Frankfurt as early as 1891. The essential feature of a.c. systems was, of course, the practical transformer, though supply frequencies were often as high as 133 c/s and must have been very troublesome owing to overheating by hysteresis losses in the poor magnetic materials then available.

The twentieth century (1900–1950)

The state of electrical development at the opening of the 20th century is illustrated by Figs. 3 and 4, which show typical plant in telephony and in power engineering. The next few years, however, were to produce a flourish of technical achievement in all branches of engineering, not only electrical. In 1903 Orville and

Wilbur Wright made the first successful adventure in a heavier-than-air flying machine, and King Edward VII sent the first wireless message by spark telegraphy across the Atlantic to President Theodore Roosevelt. Power engineering was stimulated by the introduction of metal-filament lamps and many other electrical applications in industry and in the home.

Within 30 years we were meeting the challenge of the ever increasing demand, exploiting new materials and more efficient designs (Fig. 6). The induction motor, high-voltage generation and distribution, remote-control switchgear, electric traction—these were examples of the exploitation of existing electrical principles.

On the other hand, the really novel innovations in power engineering were electronic. The mercury-arc rectifier was developed, especially for traction, and was supplemented (not superseded) by the first commercial types of selenium or copper-oxide rectifier in 1926. Here was the original invasion of solid-state physics into the world of power, to be followed in more modern times by small germanium cells of the transistor type. Yet another major exploitation of electronic principles was the high-pressure mercury-vapour lamp which was first installed on our main roads in 1933, leading to the very wide range of gas-discharge lighting devices in more modern times.

A similar kind of technical progress was achieved in light-current engineering, except that the electronic developments were much more numerous. The challenge of public demand was met by increased size and efficiency of the telecommunication system, notably the automatic-telephone-exchange network on electro-mechanical principles, but almost every other light-current development was dependent on some kind of new electronic device.

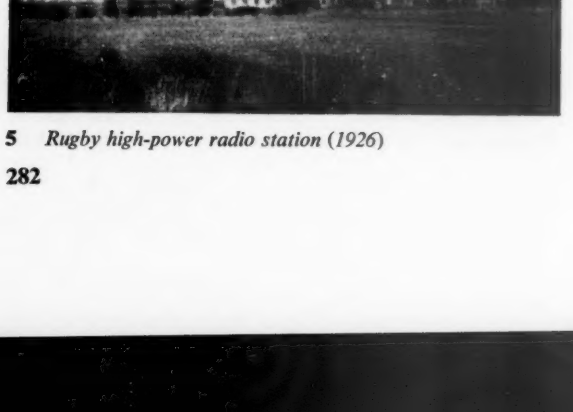
The appearance of the first practical thermionic valves in 1904–6 was the basis on which modern long-distance line- and radio-transmission systems have been created. Wireless became big business with the advent of broadcasting in 1922 and the opening of the Rugby high-power station in 1926 (Fig. 5), pumping 350 kW into the atmosphere. Then, during the last war, we had airborne radar equipment, made possible by the cavity magnetron, which produced 1 MW of energy in very short pulses—all from a device no bigger than a large ashtray. Further electronic developments on these lines provided us with entirely new systems of navigation for aircraft and ships.

Finally, a special place must be reserved for the transistor (transfer-resistor), produced just at the end of the period under review. In the course of investigating how and why the old-fashioned crystal and cat's whisker should be a rectifying device, it was noted that the electron flow was dependent on the purity of the crystal and that conductivity could be controlled by a second 'whisker' placed very close to the first. Further scientific study of semiconducting materials led in due course to the development of the more sturdy junction transistors, though we were still struggling in 1950 with the many complex problems of precision manufacture.

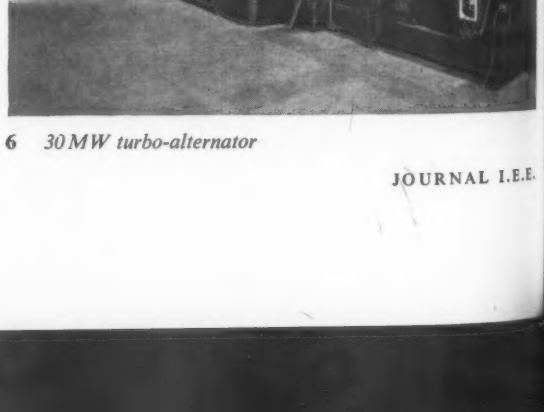
Increasing dominance of electrons (today and the future)

In this final section of the chronological review I lump together as 'today' everything that has happened since 1950, because we are too near to the events of the last few years to assess the significance of particular developments. I also wish to focus attention on electronic techniques.

In the so-called 'light-current' field, the business of transmitting information by radio, coaxial cable or waveguides is almost wholly electronic, and an all-electronic telephone exchange is due to be opened in London in a year or two; but these same techniques are finding entirely new applications in bewildering confusion. To mention only a few, we have the radio telescope, the electron microscope and automation of many kinds, all introducing a staggering reduction in our scale of time for electrical operation. The thermionic valves in the computers of 1944 were 1000 times as fast as any mechanical calculator, whereas we now hear of computers a million times faster.



5 *Rugby high-power radio station (1926)*



6 *30 MW turbo-alternator*

In the more conventional domain of the power engineer we note that modern electronic rectifiers have made possible the new high-voltage a.c. traction systems. Aircraft electrical equipment has grown from the single magneto to a complex installation rated at more than 100kW at 400c/s and using machines with rotating solid-state rectifiers instead of commutators. Is there not already a growing field of application for high-frequency heating, and what of the possibilities of electro-luminescence?

Electrical engineers, particularly those at the beginning of their careers, can no longer afford to treat electronic techniques as something for the light-current specialist alone. We cannot ignore the need for specialized electrical plant such as the electrostatic d.c. generator of several million electron-volts, the mass separator, and similar services to the new world of nuclear physics. For the scale of these electronic devices I need only mention that the synchrotron at Harwell weighs 6000 tons.

'Miniaturization' made possible

At the other end of the scale, a separate comment needs to be made on the influence of modern electronic techniques on the general reduction in size, power consumption and fault liability of electrical plant. We now have the junction transistor that does the job of the thermionic valve within the dimensions of a match-head. In storage of signals, devices such as electro-magnetic relays with relatively high energy consumption have given way to a tiny magnetic spot on a tape or drum.

A clue to far greater miniaturization was published recently in a report of storage by photochemical methods. To quote some of the final words of this report: 'the elementary switching unit can be thought of as a microscopic capsule of about 2½ microns diameter, or 100 million units per square inch if coated in a monolayer, although in practice the limits of resolution restrict the density. Such components are much more closely allied to neuron and brain structure than are diodes or magnetic cores.'

On reliability of plant, a glance back at the early versions of any engineering device, electrical or mechanical, reveals how the amount of adjustment, tuning and fiddling required on prototype models is being progressively reduced. It is a characteristic of the majority of electronic devices that their reliability is built in at the manufacturing stage and that individual adjustment thereafter is neither necessary nor indeed possible.

In other words, modern electrical plant requires greater precision in manufacture, after which it stays put without attention until the time comes to throw it away and replace it. One has only to compare the filament lamp with the arc lamp to realize how valuable this outlook on maintenance can be.

On the brink of a new concept

It is with no disrespect to the memory of Michael Faraday that we may think that electromagnetism as a basis for the exploitation of electrical energy may give way to a new approach arising from electronics and nuclear physics. The modern researches leading to Zeta would not have been possible without going through the stage of development which Faraday inaugurated, but it seems that we are now on the brink of new ways of generating, transmitting, controlling and using electricity.

Our kind of electricity has been largely imprisoned in copper wires, but electricity in nature manages quite well without copper. We are still learning how it can be sent through solid insulators, through gases and through nothing at all (or apparently nothing); there are the so-called electro-jets of hundreds of thousands of amperes in the ionosphere, and minute currents in animal muscles, nerves and brains.

We are now faced with the conception of an electric current that may be composed of either electrons or the opposite of electrons—i.e. the 'holes' defined in solid-state physics. How long will it be before a flow of electricity in bulk is obtained direct from the energy within the atom, without the intermediate stages of steam and turbo-alternators?

As individual electrical engineers we must accept these new techniques, whatever may be the specialized application with which we are immediately concerned. We—and especially the younger generation—must be prepared to learn new tricks and to make use of every new device that the physicist puts before us, whether we call it electronics or not. This means a more scientific and more mathematical approach to our professional work, without our becoming scientists as such. It is better that we should abandon the old distinction between light-current and heavy-current engineering and should realize that the one thing that binds us all together is the electron.

Electronics and The Institution

How, then, does this concept affect the organization of The Institution, with its specialized Sections? It is already stated on the authority of the Council that 'the fundamental principles of electrical engineering and science constitute a common ground of interest to all members of The Institution, and this collective unity remains undisturbed by the existence of the four Sections, which were formed for the sole purpose of facilitating discussions of matters of common interest in specialized applications of those general principles'.

The fundamental principles of electromagnetism as they existed over a century ago had all the appearance of being exclusive to telegraphy, because the first useful applications were found in that sphere. History is repeating itself. The new electronic principles have again been first utilized in the realm of telecommunication, perhaps because it is only natural to use new devices in small dimensions before embarking on larger units. Now it seems that the time has come to drop any limitation of the term 'electronic engineering' which would imply something different from electrical engineering and to

discourage any monopoly of the word 'electronics' by the light-current engineer.

There is a wide range of application of electronics to all the specialized Sections, though it may be impossible to define the classifications precisely. For instance, it is obvious that modern solid-state rectifiers are of concern to us all; and it is clear that different aspects of nuclear physics and medicine, for example, fall within the several provinces of the Electronics and Communications, Measurement and Control, and Utilization Sections; moreover, the Supply Section may be concerned with high-voltage electrostatic generators for nuclear research.

Dividing the Proceedings

It would seem that the time is rapidly approaching when the present division of the *Proceedings* between (A) 'power engineering' and (B) 'electronic and communication engineering' will have to be modified. Electronics papers that are chiefly of interest to power engineers are already reproduced in Part A, so the name 'electronic engineering' should cease to be tied to communication or radio or to any other application. If we must have titles to distinguish particular electronic techniques, would it not be better to refer to 'electronic control', 'electronic communication', 'electronic rectification', etc., each *within* the general classifications according to application?

Dr. C. C. Paterson (later Sir Clifford) opened the Faraday Lecture in 1934 with these words: 'The science of electrical engineering was born again when the physicist showed how electricity can be liberated from metal'. This assertion has been confirmed by recent events, and we should now accept the technique of electronics in its broadest sense as electrical engineering itself.

Summary

The word 'electronics' covers not only light-current electronic switching but also an increasing range of applications of modern solid-state physics and nuclear physics in heavy electrical engineering. In 1837 the first practical engineering of Faraday's discoveries was in the form of telecommunication, and the new electronic techniques have again been applied initially to light-current engineering.

More recently, electronics has invaded the domain of the heavy-current engineer, with complex mercury-arc rectifiers, dry metal rectifiers, gas-discharge lamps, high-frequency induction heating and nuclear power stations. The new electronic technology should be accepted by individual engineers and by The Institution as electrical engineering itself. That is why it is advocated that the title 'electronic engineering' should be dropped from the title of Part B of the *Proceedings* and should certainly not be associated solely with 'radio' or any other light-current application of electronic techniques.

The Summer Meeting of The Institution

FROM the 15th to 19th June 1959, the county of broad acres will, in Harrogate, open its arms to give a 'reet Yorkshire' welcome to the 400 Summer Meeting visitors. This is the first time in 25 years that the North Midland Centre have had the pleasure and honour of playing host on the occasion of a Summer Meeting; and the Centre, the Sub-Centre at Sheffield and the Districts at Hull and Catterick have combined to make it one to be happily remembered.

Pottering at the docks

The much maligned Catterick Camp is the home of the Catterick District, and the Convener, Lt.-Col. M. A. Philp, and his colleagues have prepared a programme which, it is certain, will show visitors that any tales they may have heard about Catterick are just so much hearsay. In fact, the visit might prove to show that Catterick is indeed a charming and pleasant spot.

Those members opting to go to Hull will find a full and interesting day organized for them by the Hull District Convener, Mr. H. Hilton. They will potter among ships at the docks; take tea, it is hoped, on board a Beverley transport aircraft; and admire the architectural beauties of Beverley Minster—enough to whet the appetite of any engineer or his wife.

The awe of mighty steel furnaces and mills, the splendour of the Pennine Hills and the majesty of ancient homes are the main features of the programme devised by Dr. Benson, the Sub-Centre Chairman, and his Committee for those who will go to Sheffield. They will return with a vivid memory of the furnaces and mills, the presses and forges, and a happy one of the hospitality of the men who make steel.

Cross-section of Yorkshire

The 'main Centre', as it is known in the area, under the guidance of its Chairman, Mr. J. D. Nicholson, has a mixed bag of interest to offer. Wool and textiles are synonymous with the West Riding; add to them, clothing, engineering, heavy and light radio and television engineering, glass making and others, and you have a variety to meet the most exacting of tastes. For full measure, include the Dales of Yorkshire, Harewood House, and the ancient ruins of Fountains Abbey (shown on the front cover of this number of the *Journal*), and there presents itself a cross-section of Yorkshire so complete that the difficulty will be in deciding where to go.

Provided that June is 'flaming' in the best possible sense, a successful meeting seems assured. H. A. C.

Electric power in Europe

DESPITE the slackening of economic activity in Europe in 1957, electric power consumption amounted to 717 thousand million kWh for Europe as a whole. This represents a 7% increase, as against a 10% increase in 1956. These figures were submitted* by the Secretariat to the Committee on Electric Power of the United Nations Economic Commission for Europe, which held its 17th session at Geneva from the 18th to 20th March 1959. The relative stability of the increase in electric power consumption is explained by the steady development of certain industries which are large consumers of power, such as the metal-working industries, and by the expansion of the chemical industry.

The Secretariat's report suggests that the stability of the electric power sector should encourage investment in this form of energy to take advantage of the slackening of economic activity and the easing of the money market. In certain European countries, combined production of power and heat is increasing considerably, with a consequent saving of fuel; and in view of the importance of developments in this field the Committee decided that in future they should be followed more closely. As regards power exchanges between national Grids, mutual agreement is needed on certain technical matters relating to power-frequency regulation. Close co-operation in this field has been achieved in Western Europe.

The fall in the rate of increase of electric power consumption for domestic purposes was more marked than the corresponding decrease in the industrial field, probably owing to the mild winter. As regards the increase in electric power consumption per unit of industrial product, it appears that the replacement rate is in inverse proportion to electrification. But even in the highly electrified countries there is still ample scope for replacement. The increase in the consumption of electric power is much greater than that of other forms of energy, but it is less marked in countries where electric power is already very widely used.

The problem of peak loads is becoming increasingly important because of the integration of nuclear power stations in the electric power production system. The Secretariat will continue its work on the problems connected with the covering of peak loads and will make a comparative economic study of the operation of the various means used for producing peak power, such as pumping stations, gas turbines, etc.

The Committee also examined the financing of new electric power projects; the electric power situation in Europe during the period 1947–1957; the development of transfers of electric power across frontiers and, in particular, possible exchanges of electric power between countries of Central and South-Eastern Europe; and the development of hydro-electric power stations on the Danube—existing, under construction or projected.

Exchanges of information have been carried out and are to be continued regarding the prospects of reducing building costs for hydro-electric power stations and the effect of mechanization in that connection; the interconnected working of large networks, their operation and development, and also the use of automatic devices and remote control; and the over-all design and operation of thermal power stations.

* In a report to be published shortly, entitled 'The electric power situation in Europe in 1957'.

Public mobile radio service

THE Postmaster General hopes to establish a public mobile radio service covering Manchester, Liverpool and the surrounding areas by the autumn of 1959. Both the base stations, at Winter Hill, near Bolton—which will cover the larger part of the service area—and at Lancaster House, Liverpool, will be controlled from the same centre, possibly Warrington telephone exchange.

The adoption of 50 kc/s channelling will permit the use of equipment that is in current production and has already been proved satisfactory in v.h.f. public correspondence services for shipping, i.e. 50 kc/s f.m. equipment meeting the specifications TSC 55(a) and TSC 53(d) for base and mobile stations respectively.

The system will use a common calling channel, two traffic channels for the Winter Hill station, and another two for Liverpool. The mobile stations, to be provided by the subscribers, will have to be capable of switching over all five channels. Duplex operation will be used at the base stations. Voice calling will be adopted at the outset; the possible development of selective calling will be taken up with manufacturers as a separate matter.

Three-year education programme

THE Minister of Education has announced a £54 million capital-investment programme for technical education over the three years from 1961. A building programme of £15 million for each year is expected to involve consequential expenditure of £9 million on equipment.

The new programme will provide for increases in the output of advanced students in science and technology beyond a level of 15000 a year; further expansion in educational provision for technicians and craftsmen to match the training opportunities which it is industry's task to provide for the growing number of young people who will be available for employment; and an improvement in existing facilities in the colleges, not only for teaching but also for social and recreational purposes, including hostels.

The £70 million building programme for the five-year period covered by the 1956 White Paper up to 1961 is progressing steadily. Building projects under this plan for new colleges or major extensions now number 359, and in 1958 the total cost of work started amounted to £15 million.

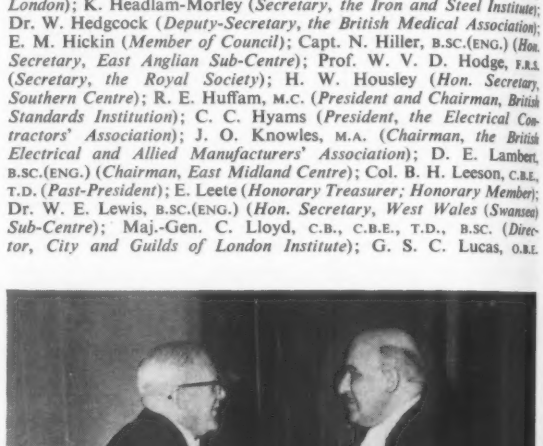
The 1959 Annual Dinner of The Institution

The Lord Chancellor on dangers in specialization

THERE were some 1450 members and guests, despite the influenza epidemic, at the Annual Dinner of The Institution at Grosvenor House, London, on Thursday, 26th February 1959. The President, Mr. S. E. Goodall, M.SC.(ENG.), F.Q.M.C., was in the chair.

Among those present were:

The Rt. Hon. The Viscount Kilmuir, G.C.V.O. (*Lord Chancellor*); Her Excellency Mrs. Vijaya Lakshmi Pandit (*High Commissioner for India*); His Excellency Mr. H. J. McCann (*Ambassador for the Republic of Ireland*); His Excellency Tunku Ya'acob, P.M.M., C.M.G. (*High Commissioner for the Federation of Malaya*); His Excellency Baron Bentinck (*Ambassador for the Netherlands*); Sir Gilbert Rennie, G.B.E., K.C.M.G., M.C. (*High Commissioner for the Federation of Rhodesia and Nyasaland*); Herr Dietrich Keller (*Counsellor, representing the Ambassador for the Federal Republic of Germany*); Dr. J. G. Malloch, M.B.E. (*Scientific Attaché, representing the High Commissioner for Canada*); The Rt. Hon. The Viscount Falmouth; The Rt. Hon. The Viscount Simon, C.M.G. (*Chairman, Port of London Authority*); Sir George H. Nelson, BART., LL.D. (*Past-President*); Sir Noel Ashbridge, B.SC.(ENG.) (*Past-President; Honorary Member*); Sir Ben Barnett, K.B.E., C.B., M.C. (*Chairman, Commonwealth Telecommunications Board*); Sir Harold Bishop, C.B.E., B.SC.(ENG.) (*Past-President*); Marshal of the Royal Air Force Sir Dermot A. Boyle, G.C.B., K.C.V.O., K.B.E., A.F.C. (*Chief of the Air Staff*); Prof. Sir Lawrence Bragg, O.B.E., M.C., F.R.S. (*Fullerian Professor of Chemistry and Director of the Davy–Faraday Research Laboratory, the Royal Institution of Great Britain*); Air Chief Marshal Sir Walter Dawson, K.C.B., C.B.E., D.S.O. (*Air Member for Supply and Organization*); Sir Josiah Eccles, C.B.E., D.SC. (*Past-President; President, the British Electrical and Allied Industries Research Association; President, the Association of Supervising Electrical Engineers; Chairman, the British Nuclear Energy Conference*); Sir John Hacking (*Past-President*); Brig. Sir Lionel H. Harris, K.B.E., T.D., M.SC. (*Engineer-in-Chief, Post Office*); Air Marshal Sir Raymund G. Hart, K.B.E., C.B., M.C. (*Director, Radio Industry Council*); Sir Laurence Helsby, K.B.E., C.B. (*First Commissioner, Civil Service Commission*); Sir Willis Jackson, D.SC., D.PHIL., DR.SC.TECH., F.R.S. (*Vice-President*); Sir Gilmour Jenkins, K.C.B., K.B.E., M.C. (*Permanent Secretary, Ministry of Transport and Civil Aviation*); Air Marshal Sir Owen Jones, K.B.E., C.B., A.F.C. (*President, the Institution of Mechanical Engineers*); Sir Norman Kipping, J.P. (*Director-General, Federation of British Industries*); Sir Patrick Linstead, C.B.E., D.SC., F.R.S. (*Rector, Imperial College of Science and Technology*); Sir Thomas Lund, C.B.E. (*Secretary, the Law Society*); Sir Hamish MacLaren, K.B.E., C.B., D.F.C., LL.D., B.SC. (*Vice-President; Director of Electrical Engineering, Admiralty*); Col. Sir Stuart S. Mallinson, C.B.E., D.S.O., M.C., J.P., D.L.; Sir Harry Melville, K.C.B., D.SC., LL.D., F.R.S. (*Secretary, Department of Scientific and Industrial Research*); Sir Cyril Musgrave, K.C.B. (*Permanent Secretary, Ministry of Supply*); Sir John Pickles, B.SC. (*Chairman, South of Scotland Electricity Board*); Sir Dennis Proctor, K.C.B. (*Secretary, Ministry of Power*); Sir Harry Railing, D.ENG. (*Past-President; Honorary Member*); Sir George Thomson, M.A., LL.D., SC.D., F.R.S. (*President, the Institute of Physics*); Sir Owen Wansbrough-Jones, K.B.E., C.B. (*Chief Scientist, Ministry of Supply*); W. G. Agnew, C.V.O. (*Clerk of the Council, Privy Council*); T. C. Bailey (*President, the Institute of Fuel*); H. E. Baker, M.A.; J. R. Beard, C.B.E., M.SC. (*Past-President; Honorary Member*); G. Bishop, B.SC. (*Chairman, Southern Centre*); Dr. W. T. K. Braunholtz, C.B.E., M.A. (*Secretary, the Institution of Gas Engineers*); Dr. J. B. Brennan, M.B.E., M.SC. (*Secretary, the Institution of Chemical Engineers*); E. A. Bromfield (*General Secretary, the Association of Supervising Electrical Engineers*); J. A. Broughall, B.SC.(ENG.) (*Member of Council*); R. Bruce, M.SC. (*Hon. Secretary, North-Eastern Centre*); Rear-Admiral K. R. Buckley (*Director, Naval Electrical Department*); J. T. Calvert, M.A., B.SC., M.S. (*Chairman, the Association of Consulting Engineers*); H. A. Carr (*Hon. Secretary, North Midland Centre*); Councillor David Cobbold, J.P. (*The Rt. Worshipful Mayor of the City of Westminster*); A. J. Coveney (*Past-Chairman, North Midland Centre*); A. T. Crawford, B.SC. (*Chairman, North-Eastern Centre*); A. Cooper (*Surveyor of Lands, Duchy of Lancaster*); H. Diggle, B.SC.TECH. (*Hon. Secretary, North-Western Centre*); E. Davies, B.A., LL.B.; A. G. Dawtry, M.B.E., T.D., LL.B. (*Town Clerk, the City of Westminster*); F. Day (*Hon. Secretary, North Lancashire Sub-Centre*); Sir John Dean, B.SC. (*Member of Council*); G. B. Devey (*Hon. Secretary, South-Western Sub-Centre*); J. H. P. de Villiers (*Hon. Secretary, Scottish Centre*); B. Donkin, B.A. (*Member of Council*); Dr. P. Dunsheath, C.B.E., M.A., D.SC.(ENG.) (*Past-President*); E. M. Edwards (*President, the Institution of Gas Engineers*); S. S. Eriks, O.B.E.; J. M. Ferguson, B.SC.(ENG.) (*Member of Council*); Dr. J. S. Forrest, M.A., (*Member of Council*); Richard Fort, M.P. (*Chairman, Parliamentary and Scientific Committee*); F. F. Freeling (*Hon. Secretary, Western Centre*); P. W. R. Gatliff, B.SC. (*Hon. Secretary, North Staffordshire Sub-Centre*); T. E. Goldup, C.B.E. (*Immediate Past-President*); D. W. Gregory (*Hon. Secretary, South-West Scotland Sub-Centre*); W. A. Guttridge; R. J. Halsey, C.M.G., B.SC.(ENG.) (*Member of Council*); Dr. C. F. Harris, M.D. (*Vice-Chancellor, the University of London*); K. Headlam-Morley (*Secretary, the Iron and Steel Institute*); Dr. W. Hedgcock (*Deputy-Secretary, the British Medical Association*); E. M. Hickin (*Member of Council*); Capt. N. Hiller, B.SC.(ENG.) (*Hon. Secretary, East Anglian Sub-Centre*); Prof. W. V. D. Hodge, F.R.S. (*Secretary, the Royal Society*); H. W. Housley (*Hon. Secretary, Southern Centre*); R. E. Huffam, M.C. (*President and Chairman, British Standards Institution*); C. C. Hyams (*President, the Electrical Contractors' Association*); J. O. Knowles, M.A. (*Chairman, the British Electrical and Allied Manufacturers' Association*); D. E. Lambert, B.SC.(ENG.) (*Chairman, East Midland Centre*); Col. B. H. Leeson, C.B.E., T.D. (*Past-President*); E. Leete (*Honorary Treasurer; Honorary Member*); Dr. W. E. Lewis, B.SC.(ENG.) (*Hon. Secretary, West Wales (Swansea) Sub-Centre*); Maj.-Gen. C. Lloyd, C.B., C.B.E., T.D., B.SC. (*Director, City and Guilds of London Institute*); G. S. C. Lucas, O.B.E.



The Lord Chancellor is greeted by Mr. Goldup

(*Vice-President*); H. Lyon, M.C., M.A. (*Director, Public Schools Appointments Bureau*); A. McDonald, B.SC. (*Secretary, the Institution of Civil Engineers*); J. McKeever, B.SC.(ENG.) (*Hon. Secretary, Irish Branch*); F. C. McLean, C.B.E., B.SC. (*Member of Council*); Dr. J. S. McPetrie, D.SC. (*Past-Chairman, Electronics and Communications Section*); Dr. D. C. Martin, B.SC. (*Assistant Secretary, the Royal Society*); C. T. Melling, C.B.E., M.SC.TECH. (*Vice-President*); B. L. Metcalf, B.SC.(ENG.), (*Member of Council*); G. Millington, M.A., B.SC. (*Chairman, Electronics and Communications Section*); Dr. J. R. Mortlock, B.SC.(ENG.) (*Member of Council*); J. Muil (*Registrar and Secretary, the Professional Engineers Appointments Bureau*); A. H. Mumford, O.B.E., B.SC.(ENG.) (*Vice-President*); J. D. Nicholson, B.SC. (*Chairman, North Midland Centre*); A. H. F. Olson (*Vice-President, the Illuminating Engineering Society*); Dr. H. E. Page (*Scientific Director, Office of Naval Research, American Embassy*); A. A. Part, M.B.E., C.B. (*Under-Secretary, Ministry of Education*); D. W. Pattenden (*Hon. Secretary, Tees-Side Sub-Centre*); H. S. Petch, B.SC.(ENG.) (*Past-Chairman, Measurement and Control Section*); J. D. Pierce (*Past-Chairman, East Midland Centre*); Prof. A. J. S. Pippard, M.B.E., D.SC., F.R.S. (*President, the Institution of Civil Engineers*); H. T. Price (*Hon. Secretary, East Midland Centre*); H. V. Pugh (*Member of Council*); J. A. Ratcliffe, O.B.E., M.A., F.R.S. (*President, the Physical Society*); R. J. Rennie, B.SC. (*Chairman, Scottish Centre*); J. Richmond, M.B.E., B.ENG. (*Hon. Secretary, Rugby Sub-Centre*); B. G. Robbins, M.SC.(ENG.) (*Secretary, the Institution of Mechanical Engineers*); Maj.-Gen. G. N. Russell, C.B., C.B.E. (*President, the Institute of Transport*); J. R. Rylands, M.SC., J.P. (*Member of Council*); Prof. M. G. Say, PH.D., M.SC., F.R.S.E. (*Past-Chairman, Supply Section*); D. P. Sayers, B.SC. (*Chairman, Supply Section*); Gurbachan Singh (*Principal Private Secretary to the High Commissioner for India*); R. Somerville, C.V.O. (*Clerk of the Council, Duchy of Lancaster*); R. W. Steel (*Chairman, Western Centre*); C. E. Strong, O.B.E., B.A., B.A.I. (*Member of Council*); Dr. G. B. B. M. Sutherland, F.R.S. (*Director, the National Physical Laboratory*); J. Sykes (*Hon. Secretary, Sheffield Sub-Centre*); G. I. Thomas, B.SC. (*Hon. Secretary, South-East Scotland Sub-Centre*); D. H. Tompsett, B.SC.(ENG.) (*Member of Council*); S. Towill, B.SC.(ENG.) (*Hon. Secretary, Mersey and North Wales Centre*); J. F. H. Tyler, B.SC.(ENG.) (*President, the Institution of Railway Signal Engineers*); Maj.-Gen. L. N. Tyler, C.B., O.B.E. (*Director of Mechanical Engineering, War Office*); J. Vaughan Harries (*Past-Chairman, Utilization Section*); E. J. Vidler (*Chairman, the Cable Makers Association*); Col. C. W. G. Walker, C.M.G., D.S.O. (*Secretary, the Association of Consulting Engineers*); J. K. Webb, M.SC.(ENG.), B.SC.TECH. (*Chairman, Measurement and Control Section*); H. West, M.SC. (*Member of Council*); Dr. H. F. Willis, M.SC. (*Chief of the Royal Naval Scientific Service*); J. F. Wright (*Past-Chairman, Western Centre*); H. T. Young (*Past-President; Honorary Member*); and W. K. Brasher, C.B.E., M.A. (*Secretary*).

The dinner began with grace, said by the President.

The Lord Chancellor

The Loyal Toasts having been proposed by the President and duly honoured, the Rt. Hon. The Viscount Kilmuir, G.C.V.O., Lord Chancellor, rose to propose the toast of 'The Institution of Electrical Engineers'. He said:

'From that combination of fortitude and good manners which I see on all your faces, I can appreciate that the last words of your President to me must have been transmitted over the microphone and that you all heard them. They were "Shall we allow them to enjoy themselves a little longer, or will you begin your speech?" (*applause*)

'On receiving the invitation to propose so great a toast in one of the greatest gatherings that London has ever seen, I felt my lack of qualifications, and I was at once reminded of a former member of the House of Lords, the famous Lord Finchley. You probably remember what happened:

> "Lord Finchley tried to mend th' electric light
> Himself. It struck him dead, and serve him right.
> It is the business of the wealthy man
> To give employment to the artisan." (*laughter*)

'I have no claim to be wealthy, but I am ennobled and, as I am sure you all realize, electrically completely incompetent.

A conversation before dinner

Left to right: H.E. Mr. H. J. McCann (Ambassador for the Republic of Ireland); the Lord Chancellor; Mr. W. K. Brasher, M.A. (Secretary of The Institution); H.E. Mrs. Vijaya Lakshmi Pandit (High Commissioner for India); and the President

Nevertheless, I have never been so happy to launch out on what are to me uncharted waters and expose myself to the hazards, or more properly the thousand natural shocks, to which Cabinet Ministers are exposed. I have in fact something which I want very much to say, but I can promise you, to your great relief, that I shall not make it too long.

'I am still suffering from a remark made by one of my colleagues in the Cabinet to me the other day. We were discussing a speech of mine, and he said "I believe that that speech will be read when Shakespeare and Milton are forgotten", but he went on to say "But not until then." (*laughter*)

'At this stage in our new scientific era, few question the importance to the whole nation—not only to the nation but to the Commonwealth—of having large numbers of highly skilled electrical engineers. I should like to give an example from my own experience in the last few months. Last September, not content with the executive, legislative and judicial pluralities of my own office, I was Deputy Lord High Everything-Else. No. 10 Downing Street I made my washpot, and over the bells of Hailsham I cast my shoe. (*laughter*) In particular, I deputized for the Commonwealth Secretary in making an appeal to, among others, this great Institution to help in founding a college of engineering technology in Delhi.

'Let me say here what an enormous pleasure it is to me, as it must be to everyone in this room, that I am able to recall this matter in the presence of the most charming and able High Commissioner we have ever had in London, Mrs. Pandit. (*applause*) I asked for help, and it was readily forthcoming. I am personally very grateful that—much more important than any gratitude of mine—on the 27th January 1959 H.R.H. Prince Philip laid the foundation stone of the college and mentioned that it was an example of friendly co-operation between the two Commonwealth countries of India and the United Kingdom.

'He went on to use these words "In addition, the Federation of British Industries and the four professional institutions

Mr. Goldup welcomes the Chief of the Air Staff, Marshal of the Royal Air Force Sir Dermot Boyle, G.C.B., K.C.V.O., K.B.E., A.F.C.

—the Civils, the Mechanicals, the Electricals and the Chemical Engineers—are to sponsor a fund to raise £250000 for equipment. I think that this is a measure of the interest of ordinary companies in the United Kingdom in the technical progress of India. Now, with such a background of sensible co-operation in such a worthy cause, I have no doubt that this college will achieve very great things."

'These were great words from His Royal Highness, and in respectfully echoing these words I want most sincerely to tender to you the heart-felt thanks of Her Majesty's Government for your great help in this high endeavour. I am assured that the success of the college will reflect your readiness to help in a great project which has been so admirably launched.

'Time was when the classical criticism of educationists was that they had a traditional resistance to the reweighing of values. To use an electrical metaphor, they were bad conductors, and their resistance, far from varying, remained constant. In fact, it was very different from that happy occasion when Mr. Robert Benchley was sitting for his law examinations at Harvard and was asked to comment on the effect on international law of the Alaskan Fisheries dispute. Mr. Benchley began his answer with the words "This answer will deal with the problem from the point of view of the fish". (*laughter*)

'You are long since past those days. So well have the leading members of The Institution performed their duty of promoting the advancement of electrical science that today there has been a great change. I think that I can put it in this way: they have converted public opinion to the view that proficiency in electrical engineering is as U (I think that that is the proper modern expression) as literary scholarship, and you cannot go much higher than that. Your great Institution, by years of work, has surmounted that fence.

'The danger today is not that new forms of specialized education are refused recognition, but that all education—and, believe me, I am quite open-minded on this matter; it applies to the law just as much as to anything else—may become too narrowly specialized, a process of knowing more and more about less and less.

'I was telling my old friend the Irish Ambassador that one of his countrymen gave us a very good example of that in the court of my judicial brother the Lord Chief Justice the other day. This Irish defendant—because even the Irish can become defendants—was asked whether he pleaded guilty or not guilty, and he replied "How can I plead either guilty or not guilty before I have heard the evidence?" (*laughter*)

'This is a very real problem. It is not that I object to specialists; after all, I have made a modest living out of being a specialist for most of my life. I do not object to specialists, but what I am worried about is lest this should become exclusive. I had the good fortune—and, seriously, what good fortune it was only the subsequent unrolling of the book of history will show—to be a colleague for years, in war and in peace, of Sir Winston Churchill. (*applause*)

'He solved the problem as only Winston could. We had to consider enormously serious questions of specialized knowledge, but Winston had this business absolutely taped; he always had beside him that most lovable figure that we called "The Prof", Lord Cherwell, and "The Prof" could in an instant translate the most difficult technical problem into words of one syllable, and figures of pounds per man instead of millions per army, in order to make the technical difficulty comprehensible to ordinary minds like my own.

'I believe today that there is a wider requirement, and I say this on the basis that the importance of your expertise is admitted by all the world. There is a wider requirement from the very beginning of education that we should learn to speak each other's technical languages and not become exclusive and ostrich-like jargoneers. That is why I am so glad to see from your Annual Report, which I have read from beginning to end, how much work The Institution is doing in furtherance of its object to facilitate the exchange of information and ideas on electrical science and engineering.

'I read your Report because I have never relied, in the course of a long and chequered career, on the method of the schoolboy, who got away with it by saying to his teacher "Sir, can a boy in this school be punished for something which he has not done?" The teacher at once replied "Of course not." The boy added "I have not done my homework." (*laughter*)

'I have done my homework, and I know just as you do—because I am sure that the Report is your favourite light reading—how much The Institution is doing in this respect. The more this is done, the more likelihood there is of making this difficult world of the second part of this mad century an intelligible as well as an intelligent world. It is important that

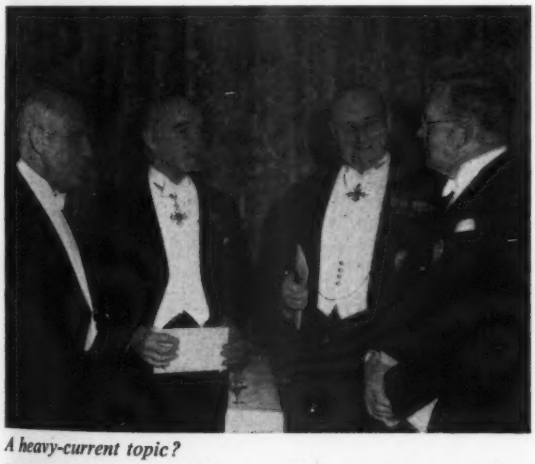
we should understand the great work which you are doing, and, believe me, we do appreciate how important it is. You, on the other hand, in your lighter moments will be able to consider the rule of law and other trivial matters of that kind which we may contribute in turn to you.

'I believe that tonight everyone in this room, and especially the President, must be pleased to think that The Institution bears every sign of the vigorous life which it has led for 88 years. The growth of your membership in the last 20 years has been phenomenal—20000 in 1940, 36000 in 1950 and, a week or two ago, over 44000. When we consider what that means and what changes in the world for ordinary people that increase in your membership represents, those are remarkable figures, and you have indeed a right to be proud.

'You have achieved recognition as a learned profession, but you realize the importance of spreading that recognition and emphasizing that the members of The Institution are not only technologists but professional men, with all that that means in a changing world in regard to the maintenance of standards and giving confidence to all who come in contact with you.

'It is a great privilege to couple this toast with the name of your President. (*applause*) It would be a work of supererogation on my part to go through the details of your President's business and professional career, on the one hand, and of all that he has done for this Institution on the other. I shall not do more than say this, and here I speak for everyone who has a sense of the sweep of the history of education, invention and discovery in our land. To fill the chair of Kelvin, the chair of Swan, the chair of Hopkinson, is no light task; but let us in this gathering show to the President, by the way we drink his health, that he is doing it to your and our entire satisfaction and to that mighty standard which these names connote.

'I ask you to drink the health of The Institution, coupling the toast with the name of your President and wishing him God-speed in his task.'



A heavy-current topic?

Left to right: Sir John Pickles, B.SC. (Chairman, South of Scotland Electricity Board); Mr. C. T. Melling, C.B.E., M.SC.TECH. (Vice-President); Col. Sir Stuart S. Mallinson, C.B.E., D.S.O., M.C., J.P., D.L.; and Sir John Hacking (Past-President)

The President's Reply

Replying to the toast, the President, Mr. S. E. Goodall, M.SC.(ENG.), F.Q.M.C., said:

'You have been kind enough, my Lord, to propose the toast of our Institution in very complimentary terms, and we thank you most sincerely for the compliments and also for the way in which you have entertained our company this evening. Ours is, as I expect you know, an applied science, and I think we can agree that even the law has some remote connection with science. In that respect, I am fond of a quotation which I believe is attributed to Charles Macklin "The law is a sort of science; it smiles in your face while it picks your pocket." (*laughter*) That, I hasten to assure Lord Kilmuir, has nothing personal about it!

'Our recognition of the importance of an adequate and well planned training for aspirants who hope to enter our profession has always been a central feature of our policy, and this principle, as probably members have noticed, is very clearly exemplified in the training that is given to the President. From the day he becomes an unassuming (I hope) but keen Vice-President, he enters on a course of very rigorous training, usually lasting about five years, in procedure, protocol, and even on occasion social behaviour. (*laughter*)

'This course is conducted primarily by our worthy Secretary, but he is aided and abetted by our experienced body of elder statesmen. When the finished product appears before you at this annual event, I am sure that there must on occasion be some doubt in your minds about the efficacy of our training methods, and tonight, you will agree, is one of those occasions.

'I hope that Lord Kilmuir will forgive me if I refer briefly to one or two topics of interest primarily to our members. As many of our guests here represent countries other than our own, I feel that it would be appropriate to start on an international note. We have always taken the view that it is one of our major responsibilities to do all we can to help our colleagues and friends in the engineering profession oversea. In a recent speech the Prime Minister referred to the good work which "is done and always has been done internationally by Britain's learned societies and institutions, whose reputation stands so high in the world". We sincerely hope, as electrical engineers, that he was in that remark including our Institution.

'When our Immediate Past-President, Mr. Goldup, stood in this place last year he announced to you that on the following day he was, on Institution business, leaving for what was in effect a world tour. He had two primary appointments, an Engineering Conference in New York and another in Australia. We should like to pay tribute to him for the excellent work which he did on that tour and also to record our appreciation of the many letters which we have received from people all along his route who clearly met him with great pleasure and appreciated what he did for them. (*applause*)

'I wish to make some reference to the scientific contribution which our Institution makes through the medium of international conventions and discussions. The number we are organizing is increasing, covering a very wide field of up-to-date topics. During this session we have already had a very successful convention on long-distance transmission by waveguide, and next month we are holding a convention

on stereophonic sound recording, reproduction and broadcasting. A month later we are to have a convention on thermonuclear processes, arranged in conjunction with the British Nuclear Energy Conference.

'The response of experts, whether members of our Institution or not, both from home and oversea, has been most encouraging, and we intend to extend this activity up to the limit which is practicable for our hard-working staff, who become very hard-pressed on these occasions. If we lay particular emphasis on collaboration with Commonwealth countries, I am sure that those of our friends who come from other countries and are here tonight will forgive us and understand our feelings in this respect.

'Lord Kilmuir has already referred to the Indian project for a new college at Delhi. We are most happy to be associated with that project, and it is a particularly happy coincidence for me that I am standing here between Her Excellency the High Commissioner for India and Lord Kilmuir, who played such a notable part in initiating the scheme in this country.

'The appeal has yet to be launched on an unsuspecting industry, and it is to be handled primarily by the Federation of British Industries. We are very grateful to Sir Hugh Beaver and Sir Norman Kipping for their work in this respect. Sir Hugh Beaver was to have been one of our principal speakers this evening, but most unfortunately he has been laid up with influenza. We are very grateful to Sir Norman for stepping at the very last moment into his shoes. (*applause*)

'I do not wish to add in detail to what Lord Kilmuir has already said, but I should like to mention that, while the Federation of British Industries are to be responsible primarily for raising the money, the general planning is the responsibility of a technical committee, and we are very happy to know that my colleague Sir Willis Jackson is chairman of that committee. (*applause*)

'I have heard only one faint note of criticism with regard to the projected scheme, a criticism with which, I hasten to add, I strongly disagree. It is to the effect that conceivably India is planning to produce too great a proportion initially of professional men in the engineering field. If this be the case—and I doubt it—all that I can say is that other Commonwealth countries will, I am sure, be very happy to absorb the surplus, because we are all suffering from a marked shortage of professional electrical engineers.

'I can speak with sure knowledge only for professional electrical engineers; but I would remind you that the White Paper on "Scientific and engineering manpower in Great Britain," published in 1956, estimated that by today, 1959, we should require some 30% more professional electrical engineers in this country than we had at that time. That target has not been reached, but it is encouraging to know that there has been a marked increase in the rate of provision of professional electrical men.

'The importance of this subject has recently been emphasized by the Prime Minister in an address which he gave at a Parliamentary and Scientific Committee luncheon, when he said "Our main duty, as I see it, is to do what we can to increase the country's scientific potential, and that means first and foremost the provision of enough trained manpower through our educational system and the development of scientific and technical teaching in our schools, technical colleges and universities." Meanwhile, we in this Institution are doing all that we can to support the developments which are going on in both the universities and the technical colleges. We also provide from time to time a forum for the discussion of the many problems involved.

'Some of our senior members have been very active in collaborating with the National Council for Technological Awards, which is at last beginning to see the first fruits of its efforts. The Diploma in Technology (Engineering) is already becoming recognized as providing an additional stream of entrants into the profession. The emphasis in the colleges recognized under the scheme is quite properly on sandwich courses. I have a feeling that Lord Kilmuir is an expert on sandwich courses, although he may not have known it before. I have been looking recently at that august list which is called the Table of Precedence, and there I read that the order is the Archbishop of Canterbury, the Lord High Chancellor, and the Archbishop of York. Gentlemen, what a sandwich! (*laughter*)

'The type of sandwich to which I am referring, however, is one in which young men—and, I hope, increasing numbers of young women—will spend alternate periods of six months approximately in a technical college and an industrial firm or group of firms. The essence of such a scheme is that the practical training in the industry and the educational training in the college shall be co-ordinated.

The President escorts Mrs. Pandit into dinner

'We are particularly happy to know that the National Council is now paying particular attention to trying to specify more closely the requirements for the practical course in the associated industrial concerns. Our chief difficulty very soon will be, I think, that, while there are sufficient places in the technical colleges, the parallel training in industry is likely to be deficient in quantity, and—dare I say it?—even now is not always what it might be in quality. We have recently appealed to the smaller and perhaps more specialist firms to follow the example which has been set particularly in Scotland of groups of companies getting together to organize a co-ordinated scheme in conjunction with the local technical college, and I sincerely commend that system to you.

'I may be talking far too much about education, and that reminds me of a story which in fact has very little to do with education: the story of a young man who was out on his first commission trying to sell a children's encyclopaedia. He went from door to door without much result and was getting very distressed, and then he came to a door which was opened by a little girl about 12 years of age. In despair he started on his propaganda with her and pointed out how remarkable the encyclopaedia was and how much it would help her at school. The little girl listened for some time, but finally she said "I don't think we need one, thank you very much, because I have just overheard my father say to my mother 'Look here, my dear, I can explain everything'." (*laughter*)

'There is, however, one other matter in the educational field that I feel I must mention briefly, and that is the recent changes made in our own regulations. There has apparently been some misunderstanding, particularly in the Provinces, with regard to the objectives, or more properly the principles, behind these changes which we have made with regard to granting exemption through National Certificates.

'It is not appropriate here to go into any details about this, but I should like to emphasize the principle on which these changes have been based, which is very clear and simple. It is this, that we want to insist on the courses of instruction which are provided standing the young men in good stead in their subsequent careers as professional men. We have very little doubt that some at least of the young men who have qualified through this channel have been at a considerable disadvantage by comparison with their university confrères. We have no desire whatever to make things more difficult for the sake of being difficult.

'Many of you will have noticed the significant change in the title of one of our four supporting sections, from "Radio and Telecommunication Section" to "Electronics and Communications Section". The word "electronics" is not a particularly happy one, and its absolute meaning is in fact extremely obscure. On the other hand, it has become very well established by usage, and many people profess to understand what it means.

'Feeling as we do that in large measure the basic education of electrical engineers should be common, we can naturally draw no distinction at all between electronic engineers and electrical engineers. Our Radio Section has, of course, always covered quite adequately the requirements of the electrical engineer who is engaged in the development and study of basic electronic principles. The applications of electronics, however, are so wide that they in fact impinge on nearly all the activities of our three other Sections, and I would say quite categorically that we have no intention of diverting appropriate papers on specific applications from those other three Sections.

The President replies to the toast of The Institution

'This will not be the last change in our structure, and consideration is already being given to the next appropriate step which might be taken to demonstrate clearly to the young man who is attracted by the electronics field that he can find all that he requires at the professional level within our learned society.

'I have already mentioned the international conventions which we are holding, and these provide one of the reasons why we have found it necessary to begin building operations at Savoy Place. The building scheme as a whole will, I hope, be complete by the end of next year; and it will provide first-class facilities not only for our normal activities but also for national and international conventions, exhibitions and the like. A large sum of money is being spent on these operations, but I am very happy to say—and I am sure that our industrial friends will welcome this—that we shall not be launching any appeal either to industry or to our members. We have a very large building fund already available, and the rest of the money we shall provide by appropriate annual amounts in our normal accounts.

'In conclusion, I wish to thank the Lord High Chancellor once again for the admirable way in which he was kind enough to propose this toast, and I express our appreciation of the interest which he has shown in our profession by undertaking this task this evening.'

Mr. Goldup and the guests

In proposing the toast of the guests, Mr. T. E. Goldup, C.B.E., spoke as follows:

'It is my privilege to be entrusted with the task of proposing the toast of the guests, a task which traditionally falls to the

Immediate Past-President. It is a task of some difficulty and complexity, as Past-Presidents know quite well: it is necessary to strike a very fine balance between a long speech which may become boring and a short speech which may be looked on as discourteous to our distinguished guests. In referring to the length of the speech, I am reminded of an amusing incident which took place during my year of office when I was a guest at an important dinner in the Provinces and sat at a table where there were what I would call some of the hard core of regular diners-out.

'The toast list was a long one, and there were six or seven speeches. One of the fellow-guests at our table suggested that we should relieve the monotony by having a competition about how long each speech would last. This was done, and I noticed that some people were very accurate in their forecasts until it came to the speech proposing the toast of the guests, for which times varying from 15 to 35 minutes were suggested. Actually, the speech lasted for only four minutes, much to the consternation of all concerned. In case there may be such a competition running this evening, let me say I shall be a little longer than four minutes. There is a top limit to my speech, but in fairness to all it will be just as well if I do not mention it. (*laughter*)

'I am sorry that Sir Gordon Radley is absent this evening. He was to have been here, but his presence is required by his Minister. I understand that the subject is not the cable. (*laughter*) Whatever the subject of the discussion between Sir Gordon and his Minister, I am sure that Sir Gordon has prepared himself very adequately for his task. Had he been here this evening he might have liked to hear a story of preparedness.

'It concerns the christening of the infant son of Mr. and Mrs. Jones. After the christening the vicar said "What a good baby you have, Mrs. Jones, and how well behaved! Even in the actual act of christening he did not cry." "Ah, vicar" said Mrs. Jones "we have been preparing for this for some time; for the last fortnight my husband and I have been practising on him with a watering-can." (*laughter*)

'Classification is the second difficulty with which the proposer of this toast is faced. Sir Gordon Radley last year divided the guests into two groups, the troubled and the untroubled, the troubled being those who had to make a speech and the untroubled those who had only to enjoy their dinner and the conversation of their fellow-guests. I think that that is too simple a classification for this evening, and so I am following a classification which has been suggested by Mr. Brasher.

'First of all, I welcome the Lord High Chancellor. We have been stimulated by what he has said to us, and I was extremely interested to hear him mention the meeting which he convened of leading industrialists, professional institutions and the Federation of British Industries. I am sure that if any of the industrialists present were a little doubtful about whether he would get his £250000, by the time they left the meeting there was no doubt left in their minds that they would have to provide what was required.

'It is nice that mention has been made of this appeal this evening, particularly as I have on my right Her Excellency the High Commissioner for India. This is to me a reward for her absence last year, when she was to have been here but was unavoidably prevented from attending.

'The President has kindly referred to my world tour. The dinner last year was on the eve of its commencement. My tour included a visit to India on my way to Sydney, and I remember with great pleasure the welcome which Mr. Brasher and I received at Bombay, at New Delhi and at Calcutta; it was most encouraging. The President has referred to the education of Indian engineers and technicians. I was able to see at first hand that in this respect there was a tremendous potential in India, and I am sure that the High Commissioner will agree with me that if India tackles this problem of educating her engineers to the required standard of skill, they will help a good deal in the very difficult problems which await solution in the world in regard to the increased use of science and engineering and adapting them to new manufacturing technologies.

'If I may make a suggestion to the High Commissioner, it is that this new look, if I might describe it as such, which is coming about between us in this country and India, should be fostered; and I can assure her that we here will do all that we possibly can to help India in this problem of educating her people to the required standard of skill.

'I am sorry that Mr. Malik, the Soviet Ambassador, is unable to be present. He is in Moscow attending the meetings between our Prime Minister and Mr. Khrushchev. I would pause here a moment to wish Mr. Macmillan every success in the efforts he is making to bring about good understanding between the peoples of the Soviet Union and ourselves and good understanding between their politicians and our politicians. (*applause*)

'We as engineers now know a good deal about the contribution that our counterparts in the Soviet Union have made and are making in the spheres of science and technology for peaceful purposes. We also know what they have done in the field of education, and there are many lessons which we can learn from them.

'Influenza has kept away from us this evening a large

The Director-General of the Federation of British Industries, Sir Norman Kipping, speaking on behalf of the guests

On his left are the Irish Ambassador and the Mayor of Westminster (Councillor David Cobbold)

number of distinguished guests, among whom is the High Commissioner for Ghana, who has sent his apologies.

'I am glad to welcome the Mayor of the City of Westminster. You may know the story of the mayor of a certain city who was very keen on making an appeal for the Christmas-dinner fund for the old people of his town and who ended by saying "I don't want abstract sympathy; what I want is concrete plum pudding." (*laughter*)

'We welcome the presidents and secretaries and permanent officials of many learned societies who are here with us. We are glad to have them among our honoured guests on this occasion. We also welcome the permanent secretaries and other distinguished civil servants who are our guests here, and also representatives from public bodies. At the last moment, Sir Christopher Hinton has been taken ill with influenza; and others have been attacked in the same way, so that our top table has undergone many last-minute alterations.

'We regret also that influenza has prevented from coming an old friend who has always been with us on previous occasions, the Dean of Westminster. Had he been here, I might have reminded him of an incident during his curacy at St. Peter's, Redcar, though I am not sure whether he was the curate concerned. It is the story of a young curate who had delivered his first sermon one Sunday evening. During the week he met a parishioner and asked him what he thought of the sermon, to receive the reply "It was very interesting; we did not know what sin was until you came here". (*laughter*)

'I extend a welcome to those who are interested in the great sphere of technical education and take this opportunity of congratulating the Rector of Imperial College on his recent knighthood. Speaking of education reminds me of a conversation between young George and young Fred, two schoolboys who were in the habit of visiting one another's homes frequently. Fred, when he visited George, found that George's grandmother was extremely interested in studying the Bible; and this intrigued him, and he asked George the reason. George replied "I expect she must be swotting up for her finals." (*laughter*)

'I welcome representatives from the Admiralty, the War Office and the Air Ministry. We are always glad to have them here. We have many contacts with them, and very pleasant ones. I had many during my year of office. On one occasion I was being dined at an Admiralty establishment, and the First Lieutenant proposed the toast of "Wives and sweethearts, may they never meet". (*laughter*)

'We also welcome members of the trade associations, their presidents, chairmen and secretaries. On your behalf I extend a hearty welcome to the members of the national Press and the technical Press who are with us this evening. We owe them a great deal. I must not forget the honorary secretaries of our Local Centres and Sub-Centres. They are the men who look after Institution affairs in the Provinces, and very well they do it. It is an excellent idea to invite them as guests on the occasion of our Annual Dinner.

'Sir Hugh Beaver was to have replied to this toast, but unfortunately he is a victim of influenza, as you have heard. It is a sobering thought that in spite of all our knowledge and skill, influenza can still knock us sideways and upset many of our plans. We know Sir Hugh as President of the Federation of British Industries and also as President of the Institution of Chemical Engineers. Chemical engineers, with the dignity of their Royal Charter, are going forward very well under the guidance of Sir Hugh to make their Institution such that we shall all benefit in the long run from chemical engineering and not, as perhaps we do at the moment, lag behind other countries in this important field.

'I now come to our dear old friend Sir Norman Kipping. He is one of us, because he is a full member of this Institution. We all know of the contribution he has made in industry and in the Government, and of the excellent work that he has done for the Federation of British Industries, and, not least, of his interest in the F.B.I. scholarship scheme. Who better could we have to step into the breach this evening than Sir Norman? On behalf of the members of The Institution, I welcome him and thank him for honouring us by his presence and for his willingness to accept at short notice the duty of replying to this toast.'

Sir Norman Kipping responds

In reply to the toast of the guests, Sir Norman Kipping, J.P., said:

'I have at one point an advantage over Mr. Goldup, who told us about young Jones who was trained for his christening by his parents practising on him with a watering-can, because I know what happened to young Jones. About eight years later he went to his prep. school, and on the first day the master lined up the new boys and asked for their names, to fill in the register. When he got to young Jones and asked his name, the boy replied "John Blast Jones, Sir." The master asked him to repeat it, and then to spell it, which he did, "B–l–a–s–t". The master said "How did you come by a name like that?", to which the boy replied "Father tripped on the steps at the christening, Sir". (*laughter*)

'Being myself a substitute, I feel that The Institution does not understand the rules of cricket. A substitute is allowed to catch the other side out but is not allowed to bat. This evening, however, makes a nice change from an overdose of the problems of European trade. The difficulty in that field is that no one knows how to solve the problem or, to use a colloquial expression, what to buy for it. The Institution, in inviting guests to this Annual Dinner, did know what to buy for them and has done it most admirably. All your guests will wish me to thank you.

'Two years of talks about European trade have compelled many of us to become familiar with yet another new jargon. "Harmonization" is a term indicating a high degree of lack of harmony. (*laughter*) Rules of origin are devised to try to ensure that countries cannot avoid being honest when they claim the goods are made in Britain or France or some other country. "Discrimination" or "preference" are terms which mean exactly what the dictionary says that they mean when practised by other countries; when practised by one's own they take on a diffused glow, hallowed by long usage and Commonwealth relations. (*laughter and applause*) The term "quota" is derived from the Latin word "quot", which means, I believe, "how much". It is being taken by certain nations to mean "how little".

'In recent months I have spent many hours sitting in metal tubes flying from capital to capital and have become all too familiar with the airports of places such as London, Amsterdam, and Copenhagen bathed in fog; and if you notice a frenzied or frustrated air about me, it has more to do with European air travel than with European trade. Both sorts of fog are beastly and involve much patience and endurance, but they disperse in the end, and I feel that the trade fog will ultimately prove no exception.

'It is a relief to turn to the congenial subject of Delhi University. British industry, particularly the British electrical industry, has a record second to none in the financial support which it has given for selected educational purposes. The operative word is "selected". The Delhi project falls very much into that category. If sometimes leading firms feel that they are regarded as milch cows and expected to stand patiently in the stall and be milked of very large sums by the most modern methods, it is not surprising.

'There has been far too wide an assumption that industry will pay for new laboratories, British textbooks oversea, patronage of the arts, rebuilding of churches, training of apprentices, foremen and managers from all over the world, and so on. One of the most deeply embedded traditions of British governments, whatever their colour, and despite the avowed policy of one of them, is to lean heavily on British industry, but they must be careful not to make the cow sick or stubborn by over-milking. The best way in which the Government could help would be to recognize that donations of this kind should be afforded special consideration for tax purposes, possibly even on American lines.

'So far as the Delhi project is concerned, however, I am sure help will be willingly given, the more so because Sir Willis Jackson himself has studied the project in detail and given it his blessing. I feel sure that we should like the High Commissioner for India to know two things. First, that a great many British people and firms have a very warm place in their hearts for her country and wish to play their part in helping it, and secondly that a very great many British people have a very warm place in their hearts for the High Commissioner herself. (*applause*)

'Your guests must all have been impressed by this massive gathering of electrical engineering talent, consisting of those who invent and design and those who make, install, use or sell their inventions. It was 30 years ago that I was admitted a member of The Institution, and I am now very out of date. The other day I was asking somebody who knew to explain the difference between a digital and an analogue computer. He said to me "If you asked a digital computer to define Marilyn Monroe, after a period of thought it would say to you "40—25—36"; whereas if you asked an analogue computer the same question, after a similar period of thought it would say "Whew-oo-oo". (*laughter*)

'Your guests must also have been impressed by the quite remarkable feat performed this evening of serving a feast to so large a gathering, hot, in good time, in good style and in good temper. Those of us who know a little of production organization inside a factory have some idea of what is involved behind the scenes and on the floor. One of the waitresses, pushing between me and one of my neighbours an hour or so ago, remarked "Well, you two are the tightest of all" —and that was before I made my speech! Once again, I thank you on behalf of your guests for your great kindness to us.'

Programme of the International convention on Transistors and associated semiconductor devices

THIS Convention (see p. 273), arranged by the Electronics and Communications Section, will take place at Earls Court from the 21st to 23rd and 25th to 27th May 1959. Papers and lectures to be presented are listed below; an asterisk denotes that a preprint is obtainable in advance on application to the Secretary.

These preprints are obtainable in sets only, as follows: Set 1—Specialist (S) sessions (not dealing with applications); Set 2—Specialist sessions (applications); Set 3—General (G) sessions (not dealing with applications); Set 4—General sessions (applications).

Opening Session (10.30 a.m., 21st May)

Opening address by the Rt. Hon. The Viscount Hailsham, Q.C., Lord President of the Council

Opening lectures by Prof. J. Bardeen, PH.D., M.S., W. H. Brattain, PH.D., M.A., B.S., and W. B. Shockley, D.SC., PH.D., B.S.

Session G 2—Materials (afternoon, 21st May)

Germanium and silicon by T. R. Scott, D.F.C., B.SC.

AFTER a historical survey, the author discusses the theory of semiconductors and shows the usefulness of germanium and silicon. Problems of high-grade production are examined.

Auxiliary materials in transistor technology by W. C. Dunlap, Jun.

THE lecture will cover the physical, chemical, and electrical properties of auxiliary materials used in transistor production where these properties are important to transistor work, and especially where the material is in contact or otherwise interacts with the primary transistor materials.

Properties and applications of some binary and ternary semiconducting compounds by Prof. H. Welker

***Growing of 5kg single crystals of germanium** (*2934*) by J. G. Wilkes, B.SC.

Silicon-ingot-growing furnace using electron-bombardment heating (*3020*) by D. B. Gasson

A NEW type of furnace for preparing single-crystal ingots of silicon by the Czochralski technique is described. The ingot is pulled from a melt resting on the parent solid material, which in turn rests on a cooled metal hearth.

Gas-phase doping of silicon (*3022*) by J. Goorissen and A. M. J. G. van Run

SILICON crystals are doped from the gas phase during floating-zone treatment in such a way that a constant resistivity results.

***Use of etchants in assessment of semiconductor crystal properties** (*2941*) by P. J. Holmes, M.A., PH.D.

ATTENTION is directed to the large variety of information, e.g. concerning electrical properties and device manufacture, which may be obtained from close examination of suitably etched germanium and silicon samples.

Session G 3—Basic theory (morning, 22nd May)

Fundamentals of junction transistors by G. King, B.SC.(ENG.)

RECENT advances in fabrication and understanding of *p–n* junctions are considered in connection with their effects on transistor performance.

Modern approach to semiconductor and vacuum device theory by Prof. R. D. Middlebrook

THE speaker follows up the basic charge-control approach, integrates the treatment of current flow *in vacuo* and in a solid, and derives in a remarkably simple manner the salient features of vacuum and semiconductor diodes and triodes.

Factors that determine the high-frequency performance of transistors by J. R. A. Beale

***Some properties and applications of space-charge-limited currents in insulating crystals** (*2928*) by G. T. Wright, PH.D.

THE mechanisms of current through insulators in the presence of surface potential barriers and electron traps are examined, and the simplified theory of space-charge-limited current through insulating solids is described. Possible applications are discussed.

***Recombination of excess carriers at a silicon–electrolyte interface** (*2877*) by H. U. Harten

TO illustrate the dependence of the recombination on the surface potential according to the Stevenson–Keyes curve, the recombination velocity is investigated by observing the photovoltaic effect of a *p–n* junction alloyed to one surface of a thin silicon disc which is illuminated by non-penetrating light on the other side.

***Review of recombination mechanisms in semiconductors** (*2964*) by P. T. Landsberg, M.SC., PH.D.

THE survey is given in terms of elementary physical processes, and a division between avoidable and unavoidable recombination mechanisms is used.

Session S 4—Materials (morning, 22nd May)

***Diffusion of aluminium to the surface and to dislocations in silicon** (*2873*) by R. Bullough, B.SC., PH.D., R. C. Newman, B.SC., PH.D., and J. Wakefield, B.SC.

A QUANTITATIVE study is made of the formation of *p–n* junctions produced by the preferential diffusion of aluminium relative to phosphorus in silicon. Cylindrical *p–n* junctions have been formed round individual dislocations.

Ultrashort lifetime apparatus (*3015*) by C. Gordon Peattie, PH.D., W. J. Odom, B.SC., and E. D. Jackson

***Note on the use of filters in photoconductive decay measurements** (*2885*) by A. C. Sim, B.SC.(ENG.)

A THEORETICAL analysis and discussion are given of the effects of the varying depth of absorption of photons in photoconductive decay experiments for the measurement of excess carrier lifetime and of surface recombination velocity.

Dislocation planes in semiconductors (*2967*) by H. F. Mataré, DR.ING.

DISLOCATION planes are considered from the aspect of their influence on carrier transport.

***Influence of surface properties on the characteristics of formed point contacts on *p*-type germanium** (*2935*) by B. H. Claussen

THE factors influencing the properties of formed whisker contacts on *p*-type germanium are examined in the light of an electroforming theory proposed by Drake and Sim.

Dark-spot method for measuring the diffusion constant and length of excess charge carriers in semiconductors (*2997*) by A. C. Sim, B.SC.(ENG.)

State of etched semiconductor surfaces as revealed by electron diffraction (*2998*) by P. J. Holmes, M.A., PH.D., and R. C. Newman, B.SC., PH.D.

Preparation of single-crystal silicon for the production of voltage-reference diodes by G. Ashton and M. H. Issott

Session G 5—Characteristics and their measurement, and transistors as a circuit-element (afternoon, 22nd May)

Characterization and properties of devices by the late J. J. Ebers (presented by M. Sparkes)

CHARACTERISTICS, performance and limitations of currently used and new transistor and semiconductor devices are outlined.

Radio-frequency measurements on transistors by F. J. Hyde, M.SC.

ACCURATE measurement of transistor parameters is discussed, with particular reference to the alloy types of diffusion and drift transistor.

Accelerated ageing experiment on germanium *p–n–p* alloy-type transistors (*3008*) by F. F. Roberts, B.SC.(ENG.), J. C. Henderson and R. A. Hastie

Reliability appraisal of semiconductor devices (*2980*) by R. Brewer and W. W. D. Wyatt

THE incidence of inoperative failures, the trends shown by measurements of major characteristics during life, and the form of life survival curves are surveyed.

Characteristics of silicon voltage-reference diodes by A. E. Garside, B.SC.(ENG.), and P. Harvey

Power rating of semiconductor rectifiers by J. I. Missen, M.SC.

SOME of the factors which influence the rating of germanium and silicon rectifiers are given.

Environmental effects on the growth of excess reverse current in germanium *p–n* junctions by J. I. Carasso, B.SC.

Measurement of transistor characteristics at v.h.f. (*3019*) **by J. H. Bagley, B.A.**

THE paper is concerned with the evaluation of transistors for use as small-signal v.h.f. amplifiers. Descriptions of suitable methods of parameter measurement are given.

Session S 6—Basic theory (afternoon, 22nd May)

The design theory of avalanche injection diodes by A. F. Gibson, PH.D.

TWO-TERMINAL avalanche devices are described with switching times in the millimicrosecond range.

***Electrical breakdown in germanium *p–n* junctions** (*2916*) by J. Yamaguchi and Y. Hamakawa

FROM experiment it is shown that there may be non-uniformity of junction or patch in the high electric field and that turn-over occurs when the barrier reaches the intrinsic temperature at any spot in the junction.

***Emitter efficiency and injection level in diffused structures** (*2894*) by A. K. Jonscher, B.SC., PH.D.

APPLICATION of the differential equations governing the transport of injected carrier densities in inhomogeneous semiconductors for low and high injection levels leads to the establishment of the criteria for the onset of high-injection conditions which entail the limitation of the speed of response.

***Forward characteristics of p^+–n–n^+ diodes in theory and experiment** (*2938*) by J. Shields, B.SC., PH.D.

IT is shown from the forward characteristics of p^+–n–n^+ structures that they may behave as p^+–n, p^+–i–n^+ and p^+–n^+ structures, and the factors determining the transition from one mode of operation to another are given.

Some fundamental aspects of *p–n* junctions (*2990*) by A. C. Sim, B.SC.(ENG.)

Session G 7—Characteristics and their measurement, and transistors as a circuit-element (evening, 22nd May)

Transistor equivalent circuits by R. L. Pritchard

THE speaker will deal only with the physical-model type of equivalent circuit.

Shot noise in silicon junction diodes by Prof. M. J. O. Strutt

***Current gains of diffusion and drift types of junction transistor** (*2937*) by F. J. Hyde, M.SC.

THEORETICAL aspects of the frequency-dependence of current gain are reviewed, and a semi-empirical expression for the common-base internal current gain α_d is given which closely approximates to theory.

***Approximations to alpha for diffusion transistors** (*2976*) by R. S. C. Cobbold, B.SC., and D. A. Goodings, B.A.

VARIOUS approximations of α are reviewed on the basis of expressions derived directly from the semiconductor diffusion and continuity equations.

***Noise figure of junction transistors** (*2973*) by J. M. Stewart

THE noise figure is derived from a noise equivalent circuit based on the theory of shot noise in p–n junctions and on a transistor small-signal equivalent circuit.

Some aspects of small-signal high-frequency equivalent circuits for transistors (*3009*) by L. G. Cripps, B.A.

THE dangers of approximations are illustrated using current gain and h.f. output admittance.

Resistance-network analysis of the current gain of junction transistors (*2981*) by F. C. Gair, M.SC., R. C. V. Macario, B.SC., PH.D., and R. L. Rouse, B.SC.

Determination of physical parameters and geometry of a junction transistor by S. Deb and A. M. Dor

Session S 8—Applications: line communication systems (morning, 23rd May)

***A compandor using junction transistors** (*2868*) by D. Thomson

A COMPANDOR is described for use on telephone speech circuits which gives a subjective improvement in signal/noise ratio of about 25 dB. Junction transistors are used as variable-loss elements, as control-current rectifiers and for temperature compensation, as well as for amplification.

***Application of transistors to digital speech communication systems** (*2983*) by P. L. W. Gibbons, B.SC.

THE author explains the more interesting design features of a 4-channel 5-digit p.c.m. system employing signal compression and expansion, and it is shown that an 8-digit system is a practical proposition.

***Use of semiconductor devices in p.a.m. system demodulation** (*2961*) by J. N. Barry, M.SC., and F. J. Nixon

BOTH the equipments examined are designed to operate on a 100-channel system and will provide gain of the signal information of about 40 dB.

Transistor feedback amplifiers in carrier telephony systems (*3023*) by D. F. Burman, B.SC., L. J. Fey, B.SC., and D. G. W. Ingram, B.SC.

FOR feedback amplifiers in carrier systems, the use of transistors leads to a division of the amplifiers into two classes: those with high gains and high output powers; and low-power amplifiers. Design considerations for both classes are discussed.

A pulse-code-modulation system using junction transistors by A. J. Armstrong, B.SC.(ENG.)

THE system is designed to provide a 5-digit transmission of a signal having a total bandwidth of 800 c/s.

Design considerations for multichannel telephone repeaters using transistors by D. J. R. Chapman, B.SC., and A. H. W. Vincent

Application of transistors to the generation of stable frequency supplies for carrier telephone equipment by L. J. Herbst, B.SC., PH.D., R. H. Moffatt, B.SC., PH.D., R. F. Purton, B.SC.(ENG.), and J. L. Slow, B.SC.(ENG.)

Delta modulation system using junction transistors by B. E. Williams, B.SC.

Session S 9—Applications: use of transistors in computing elements (morning, 23rd May)

Transistor circuits for a digital differential analyser (*2993*) by G. C. Rowley

PRACTICAL switching circuits using transistors are considered.

***Transistor storage and logic circuits for binary data-processing** (*2958*) by R. Herman, B.SC.

***Transistorized magnetic-core store** (*2954*) by D. Bray, B.SC., and A. C. Conway, B.SC.

THE store has a capacity of 4096 words, each of 37 bits, and was developed for a large transistorized computing system.

***Code translator for letter-sorting machines** (*2957*) by J. D. Andrews

THE translator, which has a maximum capacity of 4000 five-character codes, uses a matrix of 5×26 rectangular-B/H-loop cores to translate the code derived from the address on the envelope into one of 144 possible output signals.

Digital correlator for processing radar information by A. L. Cain, P. Swift, M.SC., PH.D., and A. T. Watts

THE authors give details of a transistorized digital system for improving the signal/noise ratio of a search radar equipment.

Transistor circuits for a ferrite store (*3027*) by G. C. Padwick, B.SC.(ENG.), and A. L. Cain

THE authors describe the various circuits associated with a coincident-current ferrite store, all of which use transistors and no valves.

***Fast random-access diode-capacitor store using transistors** (*2952*) by A. C. Conway, B.SC.

THE store consists of 64 words of 38 parallel bits, with a random-access cycle time at any selected address of 4 microsec.

***Digital circuits operating at 1 Mc/s using transistors** (*2942*) by B. D. Simmons and D. M. Bibb

THE logic circuits use an alloy-junction transistor with an α cut-off frequency exceeding 12 Mc/s and an aluminium-bonded diode.

Session G 10—Characteristics and their measurement, and transistors as a circuit-element (morning, 25th May)

Theory of two ports by Prof. J. G. Linvill

THE two-port parameters are determined by appropriate terminal measurements at the operating point being considered and for the frequency or frequencies relevant to the application. Their relationship with performance characteristics of amplifiers is applicable for all two-port structures, independent of their physical construction.

Avalanche transistors as fast pulse generators by J. L. Moll

THE speaker will deal with results based on the Hamilton, Gibbs and Shockley method of analysis, in which the stored minority charge is considered the variable of primary interest.

Effect of carrier storage in the emitter on transistor input admittance (*3007*) by J. J. Sparkes

A VARIATION with frequency of the emitter–base capacitance and emitter–base conductance in the hybrid-π common-emitter equivalent circuit which differs from that predicted by Giacolletto is reported.

***Transistor switching-circuit design using the charge-control parameters** (*2970*) by R. Beaufoy

Graphical methods for network design including transistor circuits by J. Zawels, PH.D., M.SC.

Transient response of junction transistors and its graphical representation (*3003*) by A. Kruithof

THE author discusses the nature of the transitions taking place when a junction transistor is switched from one working point to another and provides diagrams illustrating transient response in common-base and common-emitter configurations for normal and saturation regions.

Session S 11—Applications: industrial applications and instrumentation (morning, 25th May)

Sources of error in Hall-effect multipliers with particular reference to their use as modulators (*2989*) by A. R. Billings, B.SC., PH.D., and D. J. Lloyd, B.SC.(ENG.)

IT is shown that the errors are either due to coupling between input and output or produced by non-linear processes within the device.

Semiconductor device for fast- and slow-neutron dosimetry (*2986*) by C. A. Klein and W. D. Straub

THE authors explain work done on an arrangement combining a high-resistivity *p*-type germanium foil with thin linings of lithium 6 for estimating biologically significant thermal-neutron doses.

Precision high-voltage transistor-operated power regulators with overload protection (*3000*) by C. A. Franklin, M.SC., PH.D., P. M. Thompson, M.A., and W. M. Caton, B.SC.

THE authors consider problems in the design of regulators which can tolerate severe overloads and also meet the stringent requirements of, for example, a frequency-modulated reflex klystron operating over the range $-55°$ to $+65°$C.

***Design of d.c./d.c. push-pull transistor convertors** (*2969*) by T. Konopinski

THE author analyses waveforms in push-pull transistor convertors and presents a simple method of design.

***Solar batteries for use as the power source of unattended u.h.f. repeaters** (*2960*) by M. Kobayashi, Y. Ishikawa and K. Hayashi.

THE apparatus consists of two pairs of transmitter-receivers, each of which is partly transistorized. The entire equipment takes approximately 4–5 watts.

Design and performance of a Hall-effect multiplier (*2982*) by R. P. Chasmar, E. Cohen and D. P. Holmes

DESIGN features such as linearity, frequency response, temperature stability and circuit considerations are examined.

Gold-germanium junctions as particle spectrometers (*2992*) by J. M. McKenzie, M.SC., and D. A. Bromley, PH.D., M.SC.

THE present investigation, using protons, deuterons, α-particles, and helium-3 ions, shows that the output pulse is proportional to the incident energy provided that the particle range does not exceed the effective junction thickness.

Session G 12—Technology and design and manufacture (afternoon, 25th May)

Effect of device design on performance and quality by J. C. van Vessem

GENERAL and specific circuit performances will be reviewed, and an account will be given of encapsulation processes and preceding surface treatment.

Evolution of high-frequency-transistor design by R. B. Janes and W. M. Webster

Environmental and device cleanliness and purity standards by J. F. Pudvin

DEVICE encapsulation is also considered.

***Surface-immune transistor structure** (*2870*) by H. Nelson

A NEW transistor structure in which the base region is brought to an external surface through the central region of the collector is found to be characterized by a high degree of minority-carrier conservation and surface immunity.

***Design and performance of a high-speed silicon diode** (*2910*) by M. J. Calle, B.SC., D. Dale, B.SC., PH.D., and C. A. P. Foxell, B.SC.

THE authors first consider the various methods by which the speed of semiconductor diodes may be improved by reducing carrier storage and then the effect on the static characteristics of diodes made from silicon quenched from a temperature in excess of 1000°C.

Developmental improvements of the thermal impedance of a germanium transistor by G. P. Leroux

Session S 13—Applications: linear amplification and oscillators (afternoon, 25th May)

***Transistor stages for wide-band amplifiers** (*2892*) by G. B. B. Chaplin, M.SC., PH.D., C. J. N. Candy, PH.D., and A. J. Cole, B.SC.

SEVERAL practical wide-band amplifier circuits are described, and it is shown that they can be made to accept wide variations in transistor characteristics.

***Diode modulator for millimetre waves** (*2907*) by K. J. S. Cave, B.SC., W. Neu, PH.D., and A. C. Sim, B.SC.(ENG.)

THE authors give details of a small and inexpensive germanium point-contact diode which has been developed for the high-speed switching of a carrier at 35 Gc/s.

***Transistorized airborne teleprinter receiver** (*2975*) by W. T. Eastwood, B.SC.TECH.

Transistor sine-wave *LC* oscillators—some general considerations and new developments (*2978*) by P. J. Baxandall, B.SC.(ENG.)

***High-performance 100 kc/s amplifier and discriminator** (*2988*) by J. Willis, B.SC., and C. C. Richardson

THE amplifier and discriminator are component parts of a completely transistorized frequency-lock loop.

Session G 14—Technology and design and manufacture (morning, 26th May)

Survey of present-day techniques of manufacturing transistors by J. M. Mercier

IN this review the speaker will try to discern the basic manufacturing principles which exist among the four major groups of transistors.

Trends in transistor manufacture techniques by A. E. Anderson

THE survey covers the economics of the different manufacturing techniques.

Mechanization for production of high-frequency electrochemical transistors by S. L. Parsons

***Gauge for the precision measurement of the thickness of germanium and silicon wafers** (*2891*) by D. Baker, B.SC.

IN this gauge, which employs the optical-lever principle, frictional restraint of the moving parts is reduced to that of a knife-edge.

Automatic measurement of thickness as applied to germanium wafer production in transistor manufacture by Wing-Cmdr. C. E. Bicknell, R.A.F.(RET.)

***Investigation of the alloying technique for the fabrication of germanium *p–n–p* transistors** (*2906*) by R. E. Warren, B.SC., and H. Yemm, B.SC.

THE authors deal with the manner in which wafer thickness, size of indium dots, alloying temperature, flatness of junction, furnace atmosphere and junction area affect the limits that can be achieved in the alloying process.

Session S 15—Industrial applications: high-speed switching and timing circuits (morning, 26th May)

***New linear delay circuit based on an emitter-coupled multivibrator** (*2951*) by R. C. Bowes, B.SC.(ENG.)

A SIMPLE free-running emitter-coupled multivibrator, using germanium transistors, is described in which changes in the ambient temperature and supply voltages have only a second-order effect. This circuit is used as the basis of a monostable circuit.

***Method of designing avalanche-transistor trigger circuits** (*2944*) by G. B. B. Chaplin, M.SC., PH.D., and A. R. Owens, M.SC.

THE authors explain a method of designing trigger circuits which require no adjustment when transistors are changed.

***Sensitive transistor oscillograph with d.c. to 300 Mc/s response** (*2943*) by G. B. B. Chaplin, M.SC., PH.D., A. R. Owens, M.SC., and A. J. Cole, B.SC.

A BASIC oscillograph using a total of ten transistors, as well as a more sophisticated version with improved linearity and double-beam display, are considered.

***Transistorized central pulse generator for digital equipment** (*2893*) by D. J. Grover, B.SC., and J. M. C. Dukes, M.A.

AN automatic method of maintaining synchronism between the different waveforms by means of a servo-control system is examined.

***Transistor linear-time-base circuit for a high-current electromagnetic deflection system** (*2911*) by R. C. Bowes, B.SC.(ENG.), and M. E. Piggott

A TIME-BASE circuit using germanium transistors is presented that produces a linear sawtooth current waveform suitable for driving the magnetic deflection system of a cathode-ray tube.

High-speed digital-computer circuits using transistors as bidirectional switches (*2985*) by G. Ord, M.SC., and P. L. Lewis

THE circuits use transistors as bidirectional switches in conjunction with bistable circuits and short delay lines.

Session G 16—Applications: communications (afternoon, 26th May)

Domestic radio receivers and audio-frequency equipment by T. O. Stanley

Radiocommunications by J. H. Bagley, B.A.

Line communications including pulse-code techniques by J. R. Tillman, D.SC., PH.D.

THE use of transistors in modern systems of multichannel telephony is reviewed.

***Transistors for low-noise amplifiers** (*2933*) by C. K. Battye, M.SC., and R. E. George

THE noise properties of a transistor considered as a circuit-element (physical origins of noise are not discussed) are outlined, and a method of measurement is suggested.

Design considerations of transistorized broadcast receivers (*2977*) by W. J. Pitts, D. E. A. Harvey and J. R. Baron

CONSIDERATION is given only to circuits suitable for quantity production at economic cost. Particular attention is given to the effect of transistor 'spreads' and component tolerances on receiver performance.

Effects of variations in transistor parameters on the over-all performance of a radio receiver (*3026*) by A. M. Jones

THE author explains the effect of transistor 'spreads' on the mass-production of domestic receivers.

Session S 17—Technology (design) (afternoon, 26th May)

Performance/cost approach to transistor design (*2999*) by S. O. Johnson

THE various design elements are analysed with respect to cost factors reflected by process complexity, product reproducibility and design flexibility.

***Bidirectional transistors and their uses in switching circuits** (*2972*) by J. Evans, B.SC., PH.D., D. S. Ridler and R. W. A. Scarr, B.SC.(ENG.), PH.D.

THE authors consider the properties of bidirectional alloy-junction transistors for operation in switching circuits. Required circuit features and limitations of present fabrication techniques are outlined.

***Design and measurement of semiconductor devices in terms of thermal behaviour** (*2919*) by G. N. Roberts, B.SC.(ENG.), PH.D.(ENG.), and R. W. A. Scarr, B.SC.(ENG.), PH.D.

IT is shown how the thermal resistance of the various heat paths from the transistor junction to the surrounding air can be calculated, and an electrical resistance analogue of the transistor heat paths is described.

***Design considerations of a graded-base transistor with improved emitter–base breakdown voltage** (*2918*) by W. Fulop, B.SC., PH.D.

THE improvement is achieved by insertion of a layer of high resistivity between the emitter and the graded base.

Design of single-crystal infra-red photocells (*2965*) by C. Hilsum, B.SC., and O. Simpson, M.A., PH.D.

***Thermal-resistance considerations in the design of semiconductor devices** (*2968*) by C. A. Hogarth, B.SC., PH.D., A. Langridge, M.SC., and J. M. Ziman, D.PHIL.

IT is shown that the thermal characteristics of regions remote from *p–n* junctions may have an important bearing on the operation of the device. The problems associated with transient flow of heat are surveyed, and the use of a composite base structure is examined.

***Recent advances in the application of photolithographic techniques to semiconductor devices and microminiaturization** (*2950*) by T. M. Liimatainen

Session G 18—Applications: switching (evening, 26th May)

Pulse circuits by G. B. B. Chaplin, M.SC., PH.D.

FOUR properties of the transistor can be exploited in pulse circuits: high collector current; low collector voltage; low input voltage; and avalanche operation. It is concluded that the transistor is eminently suited to the field of non-linear applications.

Applications of transistors in a space-division electronic telephone system by H. K. M. Grosser, DIPL.ING.

THE lecture explores a particular possibility for a fully automatic telephone exchange and examines the requirements of a cross-point.

Transistors in data-processing machines by J. H. Felker

***Some switching-circuit applications of transistors and saturable magnetic cores** (*2953*) by V. B. Hulme, M.A.

THE author describes some circuits employing the special properties of junction transistors used as switches, mostly in conjunction with saturable magnetic cores having a rectangular B/H characteristic.

***Transistor applications in a high-speed parallel computer** (*2909*) by J. Connett and P. Cooke, B.SC.

THE authors explain how transistors can be used with diode logic to satisfy some fundamental requirements peculiar to binary amplifiers and two-state elements. Master pulse techniques and their application to the ferrite-core store drive are discussed.

***Combined counter and decoder using transistors and magnetic cores** (*2908*) by W. A. E. Loughhead, B.SC.TECH., Agnes A. Kaposi, G. A. Matthews, B.SC., and J. A. Woodward, B.SC.

THE working of a counter operating in the '*m* out of *n*' code, using transistors and magnetic cores, is considered, particularly the control of the pulse length of the driving and biasing stages.

Transistorized circuits for use with magnetic-drum-controlled data-handling systems (*2966*) by B. H. Capper and B. Lowe

VARIOUS circuit-elements are presented which have been designed basically for operation at 100 kc/s to perform logical functions associated with magnetic-drum storage and data-handling systems.

***Precision transistorized television waveform and pattern generator** (*2959*) by J. Schaffer, B.SC., and D. W. Furby

THE generator produces the waveforms necessary for controlling picture-generating equipment plus a composite video grid pattern signal.

Design of transistor blocking oscillators (*3013*) by P. Norman, B.SC., and E. J. E. Smith

CIRCUIT operation of monostable transistor blocking oscillators using transformer-inductance pulse-width control and a shunt load is related and analysed.

Magnetostrictive delay-line stores operating at 1 Mc/s using transistor circuits by H. A. Showell, C. W. M. Barrow, B.SC.(ENG.), and R. E. Collis

THE paper examines two magnetostrictive delay-line stores that have been developed for use in data-processing. The use of transistors has enabled the stores to be constructed in the form of compact plug-in units using printed wiring.

About shift registers containing transistors in each stage by G. Szarvas

Session S 19—Technology (manufacture) (evening, 26th May)

***Method of preparing semiconductor *p–n–p–n* switching devices** (*2886*) by R. Freestone

FOUR-LAYER *p–n–p–n* semiconductor structures, prepared in germanium by combining rate-growth and alloying mechanisms, are mounted as two-terminal devices and operate as switches which trigger into the 'on' condition when the applied voltage exceeds a certain critical value.

***Rapid sectioning of transistors** (*2864*) by J. E. Hughes, PH.D., and S. Ratcliffe

***Methods of sectioning and etching transistors for microscopic examination** (*2936*) by D. Baker, B.SC.

MACHINE lapping and polishing methods are presented for the preparation of cross-sections which accurately reveal the structure of the transistor without themselves introducing significant damage.

***Metallographic examination of semiconductor devices** (*2875*) by G. Ashton and S. Marshall, B.SC., M.SC.

A TECHNIQUE for preparing microsections of semiconductor devices is explained. The use of diamond lapping compounds for polishing enables flat sections of all the components of a device to be produced.

Sectioning and fault analysis of junction transistors (*2994*) by B. A. I. Davis, B.SC., and D. Lynton

Cold pressure welding and its influence on device design and manufacture (*2995*) by D. Boswell, B.SC.(ENG.), and R. Humphrey, B.SC.(ENG.)

MECHANICAL factors influencing the closure of envelopes by cold-welding are discussed.

Session G 20—Applications: industrial applications (morning, 27th May)

Use of transistors in instrumentation by E. H. Cooke-Yarborough, M.A.

Industrial applications of silicon controlled rectifiers by H. R. Lowry

THE characteristics of available silicon controlled rectifiers are discussed and circuits used in industrial applications surveyed.

Rectification and power supplies by D. D. Jones

THE lecture contains a summary of advantages offered by germanium and silicon rectifiers (e.g. reduced running costs in large installations) but chiefly focuses attention on certain aspects of the design of equipment using them.

***Transistorized oscillograph** (*2921*) by A. Bijl

THE instrument comprises a vertical amplifier with a bandwidth of 0·5c/s to 25kc/s, a free-running time-base sawtooth generator with a frequency range from 1 to 1000c/s, means for internal and external synchronization of the time-base generator and several supply units.

***Transistor convertors for the generation of high-voltage low-current d.c. supplies** (*2929*) by C. J. Yarrow, M.A.

A TRANSISTOR oscillator is examined in which the transformer utilizes a high-voltage resonant secondary winding. The secondary voltage is rectified to provide the high-voltage d.c. output.

***Investigation into the use of transistors in a stabilized klystron power supply** (*2940*) by J. Stephenson, B.SC.

THE complete unit, suitable for driving a low-power klystron operating from a low-voltage supply, forms the basis of a portable microwave source.

***All-transistor digital voltmeter** (*2927*) by R. C. Bowes, B.SC.(ENG.), and J. C. Gill, B.SC., PH.D.

THE digital voltmeter described measures a voltage up to 10·23mV and displays the result as a 10-digit binary number of 10μV steps.

Session S 21—Transistors as a circuit-element: circuit theory (morning, 27th May)

***Non-linear distortion in transistor class-A amplifiers at low and medium frequencies** (*2896*) by N. I. Meyer, PH.D., M.SC.

NON-LINEAR distortion in junction transistors at low signal levels is investigated over a range of frequencies extending up to about 0·2 times the cut-off frequency.

Some notes on the output capacitance of transistors by D. H. Jones and J. R. Tillman, D.SC., PH.D.

Compensation technique for reduction of performance errors of operational amplifiers by K. P. P. Nambier, M.SC., and A. R. Boothroyd, B.SC.(ENG.), PH.D.

THE possibilities of the technique are illustrated by examples of summing, integrating and differentiating amplifiers using either thermionic valves or transistors as the active elements, and results are given for a transistor amplifier.

***Intermodulation distortion in an experimental group amplifier using transistors** (*2878*) by D. H. Jones

THE common-base connection of the transistor (without the negative feedback necessary with thermionic valves) is shown to be sufficiently linear in an experimental group amplifier for output levels up to −6dBm. The factors affecting the intermodulation distortion are analysed.

Stability conditions in tuned common-emitter transistor circuits by G. Phylip-Jones, PH.D.

IT is shown that the minimum value of feedback capacitance required to produce instability depends on the number of stages in the amplifier and varies appreciably with the phase shift in the transistor.

Session G 22—Applications: industrial applications (afternoon, 27th May)

D.C. amplifiers by E. Wolfendale, B.SC.(ENG.)

DRIFT in transistor d.c.-coupled amplifiers is greater than that in valve amplifiers owing to the variation of transistor parameters. The Hall-device chopper and a sensitive temperature-controlled amplifier will be discussed in detail.

Applications of photosensitive devices by R. W. A. Scarr, B.SC.(ENG.), PH.D.

CONSIDERATION is given to those materials in which the photosensitivity of the bulk, as opposed to the surface, of the material is most significant. Properties and applications of semiconductor materials used in photosensitive devices are surveyed.

Transistor d.c. amplifier for use in analogue computers by C. M. Cundall, B.ENG., PH.D., J. K. Saggerson, B.ENG., and G. Shaw, B.SC.

Bias considerations in d.c. transistor amplifiers by R. Hanel, R. Stampfl and F. Caruso

***Application of transistors to d.c./d.c. convertors** (*2924*) by G. G. Avis, B.A.

A DESCRIPTION of push-pull circuits normally used is given, together with design procedure and an analysis of convertor losses.

Practical design problems in transistor d.c./d.c. convertors and d.c./a.c. inverters (*2984*) by T. D. Towers, M.A., B.A., B.SC.

THE author reviews the general principles of operation, as well as progress in circuit design.

Session S 23—Characteristics and measurements (afternoon, 27th May)

***Electrical characteristics of thin-base semiconductor diodes** (*2920*) by B. O'Connor, M.SC.

THE influence of device parameters, circuit parameters (where applicable) and operating conditions on the current/voltage characteristics and switching behaviour is examined.

***Design of apparatus to measure transistor small-signal parameters** (*2956*) by M. J. Gay

DETAILS are given of a logical design procedure for apparatus using techniques for measuring small-signal parameters, together with methods of checking the finished equipment.

***Apparatus for the measurement of current gain in the range 1–300Mc/s** (*2949*) by H. G. Bassett, B.SC.(ENG.

BOTH common-base and common-emitter measurements are made by injecting a current into the input lead of the transistor via a wide-band shielded transformer. The zero error introduced by the apparatus is less than 0·4dB.

Measurement of equivalent circuit parameters of transistors at v.h.f. by M. B. Das and A. R. Boothroyd, B.SC.(ENG.), PH.D.

A TECHNIQUE is presented for measuring the current gain of transistors in magnitude and phase in near-short-circuit conditions at frequencies up to some 180Mc/s.

Measurement of transistor transient switching parameters (*3006*) by J. J. Sparkes, B.SC.

NEW parameters for use in the design of switching circuits are defined, and their relation to small-signal parameters and rise and fall times is summarized.

A review of the Proceedings, Parts A and B

SHORT REVIEWS OF PAPERS

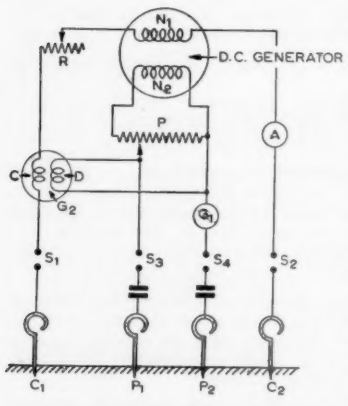
ON the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers

Geoelectric surveys

A brief review of a Measurement and Control Section paper (2791) entitled 'Examples of geoelectric surveys', by L. S. Palmer, D.Sc., Ph.D., F.Inst.P., Member. The paper was published individually in December 1958 and will be republished in Part A of the Proceedings. Dr. Palmer was formerly a consultant to Ferranti Ltd. and is a Professor Emeritus in the University of Hull. He is Honorary Curator of Wells Museum.

THE value of knowing what is below the surface of the earth is self-evident, but methods of acquiring this knowledge, other than by the expensive trial-and-error process of sinking boreholes, have not been developed with any reasonable degree of precision until recently. Early difficulties lay more in the interpretation of observations than in the design of apparatus. For deep surveys, seismic methods are most frequently used, but geoelectric techniques are convenient for investigating the nature of more superficial strata.

Geoelectric surveys in East Yorkshire, the Mendip Hills and Bristol have been carried out using a technique similar to that originally employed by Wenner* but differing in that the four electrodes inserted into the ground in a straight line (the traverse), instead of being equally spaced, are arranged so that the ratio of the distances between the inner, or potential, electrodes and the outer, or current, electrodes is kept constant. (In Fig. 1, P_1P_2/C_1C_2 is kept constant irrespective of the total length of the traverse.)



1 *Circuit schematic of apparatus for geoelectric surveys*

The station below which measurements are to be made is sited in the middle of the traverse, and the longer is the traverse the deeper does the current effectively penetrate. The earth, in fact, acts as a three-dimensional potentiometer.

Fig. 2 shows the equipment in use in the field. The hand-operated current generator is shown on the left, and the measuring instruments are on the tripod on the right.

From calculations based on observations of the current and voltage and the spatial distribution of the electrodes, a value is obtained which is termed the 'apparent resistivity' and is applicable to the rocks at a given depth below the surface. It is convenient to see how the earth's resistance varies with depth by plotting graphs of the calculated apparent resistivity against a known function of the depth.

From a study of families of such graphs, assisted by some knowledge of the local geology, it is possible to determine the size and position of such anomalies as geological faults, subterranean cavities, water-bearing strata, localized ore deposits, salt domes, buried foundations, and similar discontinuities.

Applications and examples

The interpretation of the nature of any anomaly becomes less reliable the smaller and deeper it is. As a result of these limitations, geoelectric methods are sometimes unsuitable for investigations at depths exceeding about 1000ft. In spite of this, the method has proved useful to geologists, town-planning authorities, water engineers, structural engineers, mining engineers, etc., and can usually provide the information which would otherwise have to be obtained by sinking trial boreholes.

Three practical examples of geoelectric surveys using this method are:

(1) a survey of the chalk basin beneath the boulder-clays which cover the Holderness Plain in East Yorkshire
(2) the location of the water-table in the Mendip Hills in Somerset
(3) the rediscovery of a cave—Pen Park Hole—beneath the site of a proposed housing estate in Bristol.

Fig. 3 shows graphs of apparent resistivity as a function of depth similar to some of those obtained on each of these three surveys. Fig. 3(a) is typical of many obtained on the Holderness Plain. Its interpretation is as follows: the intercept on the axis of abscissae gives the value of the apparent resistivity of the topsoil. At greater depths, the effect of the low-resistivity boulder-clays becomes apparent as the graph swings to the left. When the current begins to penetrate the high-resistivity dry chalk, the curve begins to move towards higher resistivities and ultimately becomes asymptotic to the value of the apparent resistivity for dry chalk.

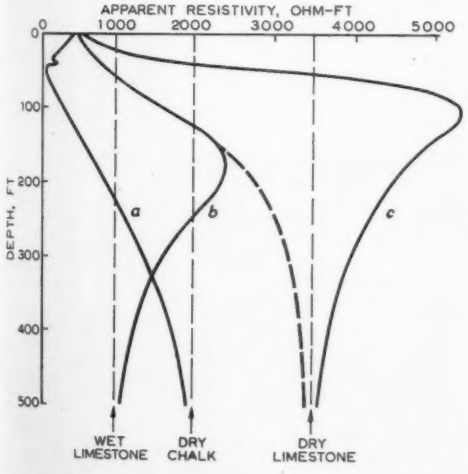
From the points of inflection on this graph it is possible

* WENNER, F.: 'A method of measuring earth resistivity', *Bulletin of the U.S. Bureau of Standards*, 1916, 12, p. 469

2 *Geoelectric equipment in use in the field*

to calculate the thickness of the topsoil and the depth of the surface of the chalk beneath the overlying boulder-clays. The kink in the graph shows where a relatively high-resistivity gravel-and-sand seam separates two layers of boulder-clay. This is geoelectric evidence for an interglacial climatic phase between the two cold periods represented by the upper and lower boulder-clays.

Fig. 3(b) was obtained on the northern slopes of the Mendip Hills in Somerset. Below a thin layer of topsoil the current passes into dry limestone, the high electrical resistivity of which causes the graph to bend rapidly to the right. This graph would follow the dotted line and become asymptotic to the value of the apparent resistivity for dry limestone were it not for the fact that the lower strata are not dry. Below the water-table the wet limestone has relatively low resistivity,



3 *Geoelectric-survey graphs*

a Parallel strata—Holderness Plain, Yorkshire
b Inclined strata—water-table in the Mendip Hills, Somerset
c A cavern—Pen Park Hole, Bristol

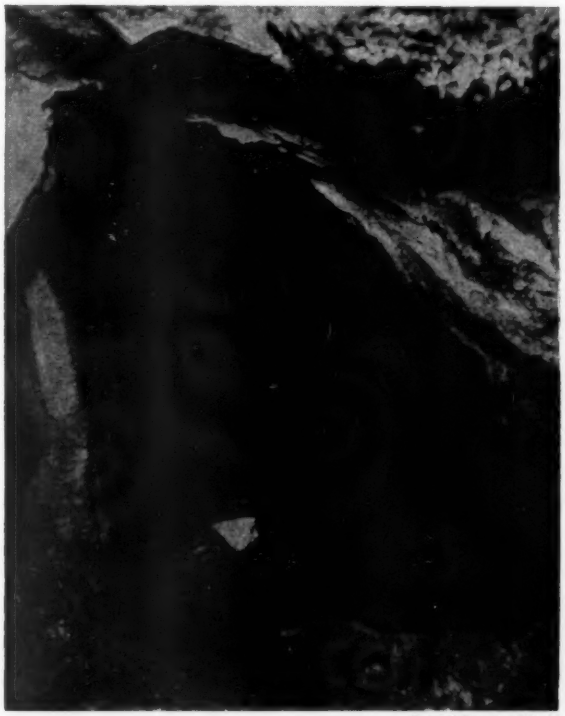
and consequently the graph swings to the left when the current enters the wet rocks. The depth of the water-table can be calculated from the value of the depth function for the lower point of inflection.

The simplicity of the interpretation of these two graphs is perhaps a little misleading, because for Fig. 3(a) the strata are parallel to the surface, while for Fig. 3(b) the water-table intersects the surface at some given angle. It is not, however, appropriate here to discuss the theoretical differences between parallel and inclined strata.

Pen Park Hole

Fig. 3(c) is the type of curve which might be expected if a high-resistivity bulge were superimposed on the dotted curve of Fig. 3(b). A bulge of this kind occurs when an air cavity is present below the station. Such a cavity presents a very high (theoretically infinite) resistance to the current, and the depth of the cavity below the surface determines the ordinate position of the bulge. But the two values are not the same: the bulge appears lower down on the graph than the depth of the cavity below the surface.

The bulge in Fig. 3(c) resulted from a large cavern—Pen



Bristol Evening World

4 *At the end of the tunnel, looking down into the main chamber of Pen Park Hole*

Park Hole (Bristol)—relatively close to the surface, but all trace of the cave and its entrances had long since disappeared. Not only was the cavern rediscovered, but also two of its old entrances were located. One entrance was a shaft in solid limestone which had been filled with clay and rubble; and, after excavating this shaft, a tunnel (predicted from the geoelectric measurements) was found which led to the main cavern. A lake at the bottom of the cavern also had been disclosed by the graphs obtained at the stations immediately above it. Fig. 4 shows the end of the tunnel where it debouches on to the side of the main cavern. The lake is over 100ft below the ledge on which the author is sitting.

These three examples of geoelectric surveys have been selected from many which have been undertaken. Another interesting survey which may be cited is that carried out with the objective of detecting and locating cavities or rifts beneath airport aprons and runways. In view of the heavy loads which such surfaces have to support, subterranean cavities might lead to dangerous subsidences if not detected and remedied. On another occasion it was necessary to determine the extent of some artificial caves which had been excavated in sandstone and above which it was proposed to build blocks of flats.

Buried water mains, gas pipes and electric conduits, because of their low electrical resistance can be mapped by geoelectric methods with considerable ease and rapidity. These are but a few of the problems which can be solved by the geoelectric engineer. 621.317.331 : 55

Influence of consumers' load/consumption characteristics on metering practice

This short account is based on a Measurement and Control Section paper (2863) with the above title, by L. B. S. Golds, Member. The paper was published individually in February 1959 and will be republished in Part A of the Proceedings. The author is with the Eastern Electricity Board.

TARIFFS are so designed that the readings of meters when translated into sums of money provide for a large part of the income of the electricity boards. For domestic tariffs alone in the year 1957–58 this amounted to about £154 million, which is about a third of the total revenue of the electricity boards.

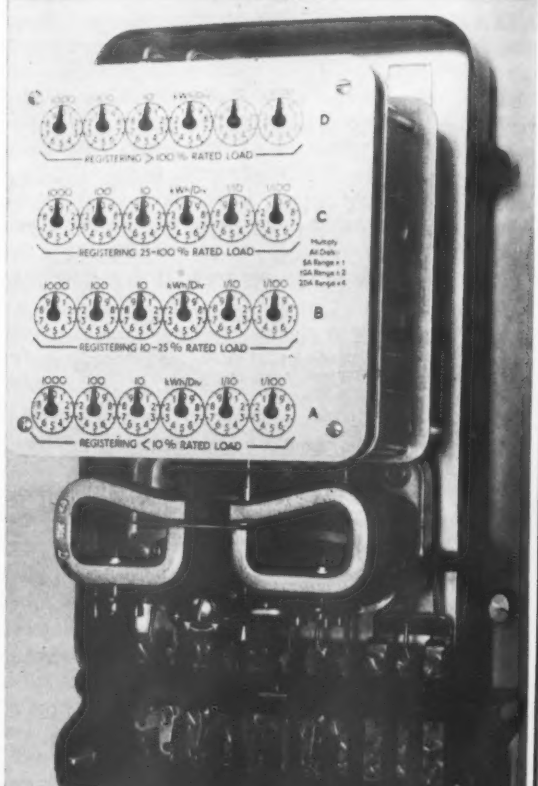
The consumer relies on the accuracy of his meter to give him a correct account under the tariff, and for this reason the measurement tolerances of kWh-meters have, since the early days of electricity supply, been governed by statute. At present errors are limited, by an order made in 1937, to 2½% high and 3½% low.

Apart from making the tariff workable, the meter serves two other functions. First, in conjunction with the tariff, it encourages diversity of use of the supply; and secondly, as a consequence, it affects the size of the mains and generating capacity. It is concluded, therefore, that the meter is a fundamental necessity in the operation of the electricity boards and the development of the supply system.

Economic service period

As the total cost of domestic-meter maintenance in the United Kingdom is around £1·4 million per annum, it is obviously essential to see whether this expenditure is reasonable and what period or periods of service are economic to the consumer and the electricity area board. The investigation recently carried out, which is a sequel to that described in an earlier paper,* was intended primarily to yield data regarding the proportion of consumption at various levels of load on the meters.

Since the errors of meters differ at different loads, it is necessary to ascertain the proportion of the consumption at those loads in order to arrive at the total energy-registration



1 *Load-analysing meter with cover removed*

* GOLDS, L. B. S., and SCHILLER, P.: 'Meter problems and consumers' load characteristics', Paper 1483, *Proceedings I.E.E.*, March 1953 (101, Part II, p. 619)

Table 1. Characteristics of samples

Sample		A	B		C'		D		National survey
(a) *Period of test*		Nov. 1950 to Oct. 1951	June 1952 to May 1953		May 1954 to April 1955		May 1954 to April 1955		1955
(b) *Consumers in territory sampled*									
Number of domestic consumers in territory		400000	37000		44000		265000		
Saturation factors									
Cooking, %		22	19		56		21		24·5
Water heating, %		11	28		7		13		20·6
Space heating, %		81	78		60		67		60·5
Average installed load (approx.), kW		5·6	4·9		7·6		3·9		5·2
Space heating (approx.), kW		2·3	1·5		1·4		1·2		1·4
Average annual consumption in territory, kWh		2250	1230		2255		1450		1540
(c) *House-service meters*									
Number in sample		110	110		110		110		
Average period since manufacture, years		14	10		10		13		
Average period since last calibration, years		10·5	6·5		8·2		5·1		
(d) *Meter size distribution*	Rating, amp	2·5	5	10	20	25	40	50	
Sample A, %		—	33	22	33	9	1	2	
Sample B, %		—	—	48	15	37	—	—	
Sample C, %		—	14	26	6	51	2	1	
Sample D, %		2	7	28	7	48	6	2	

The rating quoted is the nameplate rating and may refer to either short range or long range

Table 2. Analysis of annual consumption by load sub-ranges

Load sub-range		Proportion of consumption											
		Sample A		Sample B		Sample C		Sample D 10/40amp		Sample D 10/20/40amp		Average of all samples	
Long or short range	M.C.R. (sample D)	Proportion	Average per consumer	Proportion	Average per consumer	Proportion	Average per consumer	Proportion	Average per consumer	Proportion	Average per consumer	Proportion	Average per consumer
%	%	%	kWh	%	kWh	%	kWh	%	kWh	%	kWh	%	kWh
under 10	under 5	13	288	25	319	14	322	16	238	14	201	16	274
10–25	5–12·5	23	527	16	198	13	281	27	403	25	358	21	353
25–100	12·5–50	56	1285	48	597	50	1133	53	770	48	705	51	898
over 100	over 50	8	187	11	137	23	520	4	63	13	190	12	219
Total		100	2287	100	1251	100	2256	100	1474	100	1454	100	1744

error, i.e. the over-all error, of an integrating meter. This error can then be used to assess the service period of the meter.

To obtain the data it was necessary to design a load-analysing meter, illustrated in Fig. 1, which integrates the consumption when the load (a) does not exceed 10%, (b) is within 10% to 25%, (c) is within 25% to 100%, and (d) is over 100% of the meter rating.

Between 1950 and 1955 over 400 sets of readings extending over a 12-month period were obtained, the readings being distributed over four representative areas referred to as samples A, B, C and D.

Tables 1 and 2 show respectively the characteristics of the four samples and the load/consumption analysis resulting from the investigation.

Under-registration

In addition to the data in Table 2, the investigation revealed that up to 80% of the consumption of domestic consumers occurs in the load-current range up to 20amp and some 30% up to 5amp. Diversity of use of apparatus as well as the availability of alternative fuels are likely to prevent a rapid change in this distribution over the load-current range of the consumption and should enable an economic design of domestic house-service meter to be worked out.

The factors affecting economic metering of consumption are as follows:

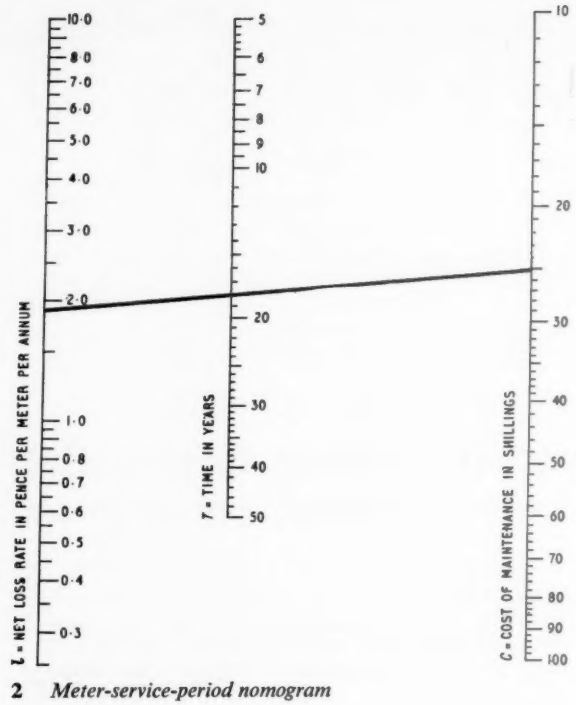
Capital cost of the meter
Annual interest and depreciation charge on the meter
Annual metered revenue
Annual cost of maintaining the meter
Quality of the meter.

While some meters may, at some stage of their life, tend to over-register, the general tendency is to under-register with the passage of time. Although the increase with time of such under-registration will not be precisely linear, it is, for periods up to 20 years, not unreasonable to assume such linearity. For longer periods, tests every 5 years would indicate the probable trend for the immediate future.

Recertification

It is shown in the paper that, if the period of time in service is T, if the net loss after the first increment of time is l, and if C is the cost of one complete maintenance operation, the period T after which it is economic to service the meter is when:

$$T = \sqrt{\frac{2C}{l}}$$



2 *Meter-service-period nomogram*

This relation is represented in the nomogram, Fig. 2, which was kindly prepared by Dr. G. F. Tagg. It should be stressed that this relation indicates a trend only and that where long service periods or long recertification periods are indicated, tests on the meter should be made to verify the approximate linearity of increase of error with time.

Since the consumers in general pay for the whole cost of electricity supply, the withdrawal of meters for recertification after a service period which unnecessarily increases the cost is not in their general interest. Clearly, there will always be a risk of the percentage error in registration of the total energy exceeding the statutory tolerances, but the error will probably be on the low side.

That risk may be calculated and the approximate value of the energy likely to be registered inaccurately balanced against the cost of returning all the meters for recertification after some period of service. This risk is approximately five times greater when the majority of the load is measured at 5% rather than at around 25% of the meter current rating. This underlines the importance of meter quality and servicing.

Conclusions

The whole investigation demonstrates that load/consumption characteristics have a considerable influence on metering practice; and if information about these characteristics is applied, substantial savings in over-all metering costs can result.

621.317.785 : 621.311.153

Discrimination between h.r.c. fuses

A short article based on a Utilization Section paper (2805) with the above title, by E. Jacks, Associate Member. The paper was published individually in January 1959 and will be republished in Part A of the Proceedings. The author is with the English Electric Co. Ltd.

In those industries which depend entirely on electricity as a power source—and this accounts for the majority—continuity of supply is more vital than ever. Faults cannot be eliminated entirely, but it is essential to limit their effects to negligible proportions. The role of protective gear has therefore become increasingly important as a means not only of preventing danger and minimizing damage but also of localizing the effects of any outages which may occur. This is the significance of discrimination.

Discrimination between h.r.c. fuses has been proved in service for more than two decades and has been almost taken for granted by most users. The new demands on electrical services have meant that protective devices have had to be kept under constant and increasingly critical review, and the h.r.c. fuses have been no exception.

The progress which has been made in recent years in improving their performance and extending their range of applicability has been considerable. This has produced new knowledge and new techniques, and it is timely to reconsider how these improved functions have affected standard practice, particularly as regards discrimination. It is of interest to consider how the new knowledge can be reconciled with established practice and contribute to further usefulness.

The paper is concerned more with the practical aspects of the subject and avoids academic treatment or mathematical analysis, both of which have been attempted elsewhere. Standard practice does not require very precise evaluation of parameters, but such approximations as are appropriate must be made on a sound technological basis. A consideration of the fundamental functions of fuse operation and performance is therefore essential. Due attention must also be paid to circuit conditions and other external factors, because discrimination is influenced as much by these as by the characteristics of the fuse itself.

The subject falls conveniently into three parts: the properties of the fuses themselves and those factors which are inherent in fuse performance in various circuit conditions; all those factors external to the fuse which are peculiar to a given installation or site condition; and the practical problems which arise in service.

Fuse characteristics

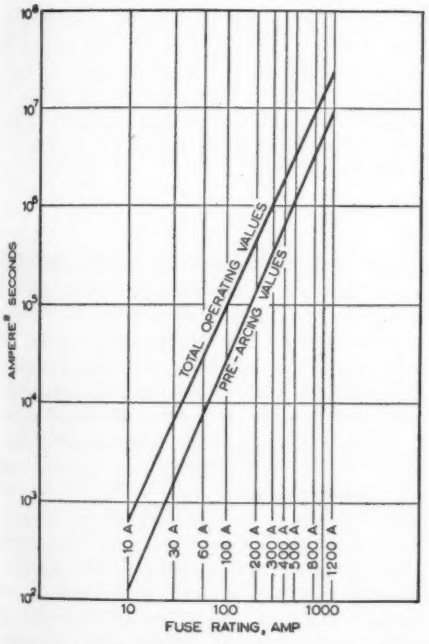
The h.r.c. fuse itself is simple in conception, but its duty is as complex as that of any other circuit-interrupting device

which has to deal with short-circuit currents of the magnitudes experienced in present-day industrial installations. It is also very largely an empirical device, notwithstanding the considerable amount of theoretical knowledge which has emerged over the last decade. Performance data are usually taken from proving tests and are a valid guide in predicting discrimination, because h.r.c. fuses can be made accurately and because their characteristics remain unchanged over long periods in service.

The problems of discrimination resolve themselves under two main headings:

Those involving low prospective currents with pre-arcing times longer than approximately 0·02 sec
Those involving high prospective currents with pre-arcing times shorter than 0·02 sec.

For the former, fuses for discrimination can be chosen from time/current curves, but for the latter it is necessary to consider I^2t values, as illustrated in Fig. 1. The I^2t concept is an important addition to h.r.c. fuse practice and has been gaining acceptance in recent times. Fig. 2 gives graphical examples of the method of making I^2t comparisons between fuses for discrimination at the higher fault levels.

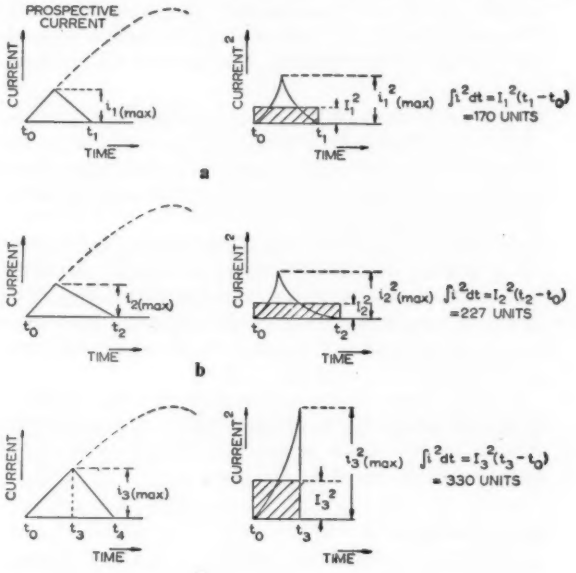


1 *I^2dt characteristics, showing relationship between total and pre-arcing $\int i^2dt$ values for a family of fuses*

The factors external to the fuse itself are not particularly critical and can usually be assessed without difficulty. Most of them can be allowed for by considering their effect early in the planning stage of an installation or by adopting 'rule of thumb' ratios between minor and major fuses.

Practical requirements

Discrimination is not always the sole criterion of a protective scheme: indeed, it must be realized that the principal purpose of the h.r.c. fuse is to provide short-circuit protection. In practice, it is necessary to recognize various degrees of



2 *Method of extending $\int i^2dt$ values from oscillograms of typical major and minor fuses*

a Minor fuse having an arcing time similar to its pre-arcing time
b Minor fuse having an arcing time twice its pre-arcing time
c Major fuse
I = (r.m.s. value of $i_2)_{t_0-t_1}$
I_2 = (r.m.s. value of $i_2)_{t_0-t_2}$
I_3 = (r.m.s. value of $i_3)_{t_0-t_3}$
Since the total $\int i^2dt$ of either minor fuse is less than the pre-arcing $\int i^2dt$ of the major fuse, discrimination will be obtained

discrimination according to the requirements of a given situation. Alternatively, it may be necessary to assess the degree of discrimination which can be obtained from an existing system which may not have been originally planned to give the best possible results.

Contingencies such as these vary with each individual installation, and an appreciation of the problems involved is best achieved by considering examples from actual experience. Several representative examples are given in the paper, showing how the degree of discrimination can be evaluated in relation to the requirements of the location. In all cases, where relaxation of the degree of discrimination is permitted, this may tolerate nuisance but must not involve danger.

The conclusion reached is that h.r.c. fuses provide discriminative protection to a degree of sensitivity well within the requirements of modern distribution practice. Failure to achieve discrimination is usually due to bad planning or to the incorrect choice of fuses. The presentation of proper data is an important factor in the avoidance of such eventualities.

621.316.923.2

Automatic graph plotter

A short article based on a Measurement and Control Section paper (2859) entitled 'A design for an automatic graph plotter', by M. P. Atkinson, B.Eng., W. T. Bane, B.Sc., Associate Member, and D. L. A. Barber, B.Sc. The paper is published this month in Part B of the Proceedings. The authors are at the National Physical Laboratory.

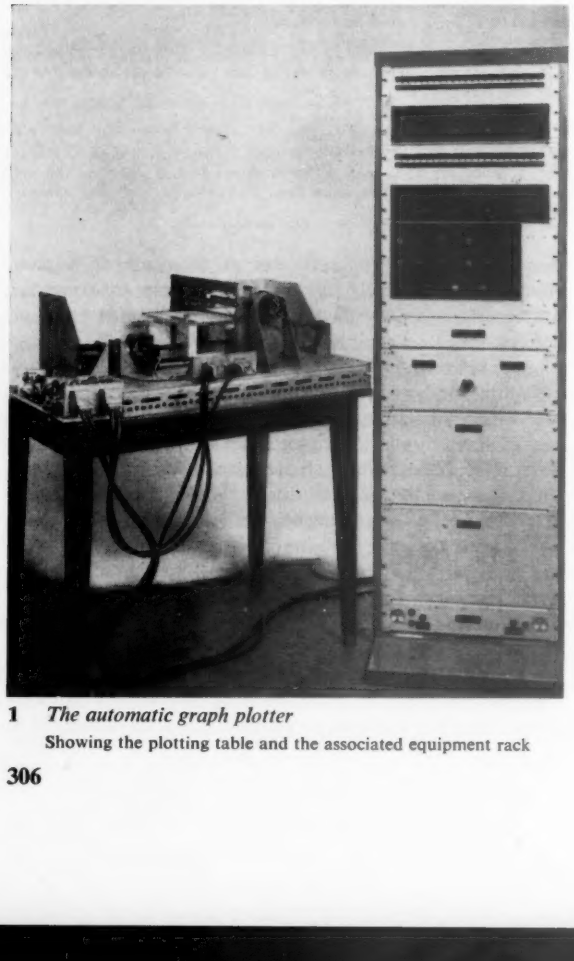
MACHINES designed to plot graphs automatically from digital information usually consist of a digital-to-analogue voltage convertor coupled to an analogue plotting table. This allows analogue techniques to be used for scaling and zero-shift purposes.

The present design makes use of digital techniques throughout to provide a system less liable to accuracy limitations than its analogue counterpart. The increased complexity of the circuit components, however, means that the system is an economical proposition only when use is made of transistors and printed-circuit techniques.

To plot a point, it is necessary to position a plotting head at a distance from a preset origin proportional to the co-ordinates of the point. The present table achieves this by using a simple digital servo on each of the two axes.

Servo principle

The principle of the servo is based on a counting technique. As the plotting head moves along an axis, electrical pulses are generated at fixed equal-displacement intervals. These pulses are subtracted from a binary digital accumulator, which initially contains a number representing the distance to be moved. When the number in the accumulator reaches zero, the plotting head is at the required position, and movement along the axis is stopped.



1 *The automatic graph plotter*
Showing the plotting table and the associated equipment rack

No attempt is made to control the speed of movement in accordance with the magnitude of the error indication, and the driving motors have only three states: 'forward', 'reverse' and 'stop'. Motion along each axis is arrested by an electromagnetic brake, operated when the appropriate accumulator registers zero, and a circuit has been designed which causes the brake to develop full torque in 4 millisec.

Scaling factors between $\frac{1}{2}$ and 1, quoted to ten binary places (1 in 1023), are achieved by subtracting from the accumulator a number equal to the scaling factor for each feedback pulse produced. The pulse is fed in parallel to chosen stages of the accumulator, as determined by the scaling factor. Short delays in the 'carry' lines between successive stages of the accumulator allow this to be done without interference occurring between direct input and carry pulses to any stage.

The scaling factor is such that for any input number the distance moved is proportional to this number divided by the scaling factor. Factors less than $\frac{1}{2}$ are obtained by multiplying the input number by 2, 4 or 8 during the process of adding the number into the accumulators initially. Using this system, the maximum possible positional error is just less than two count intervals.

Plotting points

To plot a series of points, the plotting head is first set to the position on the table which represents zero, and the accumulators are set to zero. The co-ordinates of the first point to be plotted are then added into the accumulators, and the system is allowed to run until both accumulators register zero. The point is then plotted, and its co-ordinates are subtracted from, and those of the next point added to, the accumulators, which therefore contain the difference between the two co-ordinates. The whole cycle is then repeated until all the points have been plotted.

The mechanical designs of the two axes are not identical, though the same operating principles are used. The plotting area is 10 in. square. Movement along the x-axis is obtained by moving the plotting table under a fixed gantry which carries the plotting head. In the y-direction the plotting head moves along the gantry, which is set perpendicular to the direction of motion of the table. Both systems are kinematically mounted.

The rotational movement of the driving-motor shafts is converted to linear movement along the axes by means of lead-screws. The drive to the table and plotting head is transmitted from the lead-screws by means of shaped wheels which mesh with the screw threads and are attached to the driven member. The wheels are free to rotate about their own axes and also about an axis perpendicular to this, so

that the plane of the wheels can take up the angle of the screw threads. Sliding friction between lead-screw and 'nut' is almost completely eliminated by this arrangement, and a small, low-torque motor is capable of providing the driving force required.

On each axis, the electrical feedback pulses are obtained from two phototransistors. Light from a fixed lamp falling on the phototransistors is interrupted by a slotted disc attached to the shaft of the driving motor. This disc has 20 slots equally spaced around its circumference, and the phototransistors are turned on and off 20 times during each revolution of the shafts. The signals from these phototransistors are combined in such a way that for each switching cycle a pulse appears on one of two lines, depending on the direction of rotation.

Accuracy and rate

The digital accumulators are each made up of 22 identical binary stages. Each stage, which consists of four transistors and associated components connected on a printed-circuit board, can be disconnected easily from its accumulator rack. There are two input lines to each stage, and the line which passes the carry pulse from the previous stage contains a short delay.

Transistors have been used wherever possible in the logical and operational circuits of the sequence-control system. It has been necessary to use a few slave relays to control operations of motors and brakes which require high voltages.

With pulses produced at displacement intervals of 0·005 in., the average accuracy of plotting a point is about 0·007 in., though a point can be repeated with greater accuracy. The co-ordinates are presented in decimal form and converted to binary form during the initial transfer to the accumulators. When the co-ordinates are presented to the machine in parallel, a plotting rate of 3 points/sec has been achieved for points close together.

The equipment is shown in Fig. 1.

621.374.32:681.142

High-current-density thermionic emitters

This short review is of a Radio and Telecommunication Section paper (2750) entitled 'High-current-density thermionic emitters: a survey', by A. H. W. Beck, B.Sc.(Eng.), Associate Member. The paper was published individually in November 1958, and it will be republished in Part B of the Proceedings. The author was with Standard Telecommunication Laboratories Ltd. and is now at the Engineering Laboratories, University of Cambridge.

During the last decade, intensive development effort has been applied to the production of new classes of thermionic emitter. The object of this work is to produce cathodes which will operate for many thousands of hours at current densities greater than 1 A/cm^2.

Such cathodes are vitally necessary for use in modern microwave valves using long electron beams which originate from relatively small disc cathodes. Dimensional analysis shows that, as the operating frequency is increased, the desirable cathode current density increases as the square of the frequency ratio. Since the r.f. spectrum now extends to 200 Gc/s, enormous ratios of density are encountered.

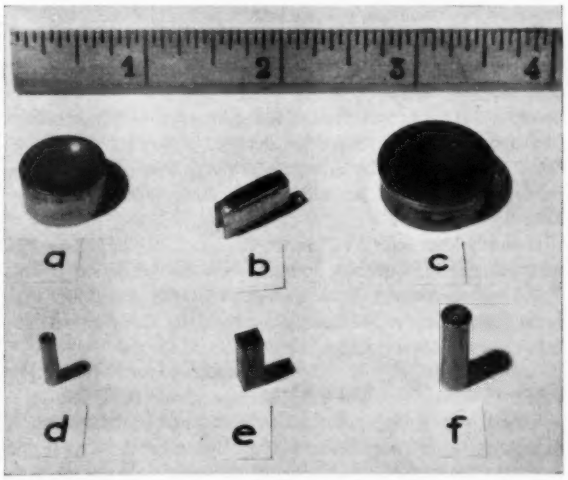
The conventional oxide cathode, as used in receiver valves, is incapable of withstanding these severe conditions for more than very limited periods, mainly because the series resistance is such that the Joule heating exceeds the radiated power at the working temperature, when densities in excess of 1 A/cm^2 are drawn from the oxide. At 1 A/cm^2 this Joule heating becomes roughly equal to the power density taken from the heater to raise the emitter to the operating temperature, and if the emission density is raised above this value the system becomes unstable.

However, up to the limit of 1 A/cm^2, there is no evidence to suggest that increased current density *per se* has a bad effect on life, and a cathode operating at 0·5 A/cm^2 in a good environment can live much longer than one operating at 0·05 A/cm^2 in a poor one.

Various palliatives have been described, including the use of very thin cathodes, cathodes in which the active material is embedded in some form of metallic mesh, etc. These expedients have been more or less successful and have extended the range of usefulness of the oxide cathode, but since the late 1940's more interest has been devoted to a new class of cathode.

Dispenser cathodes

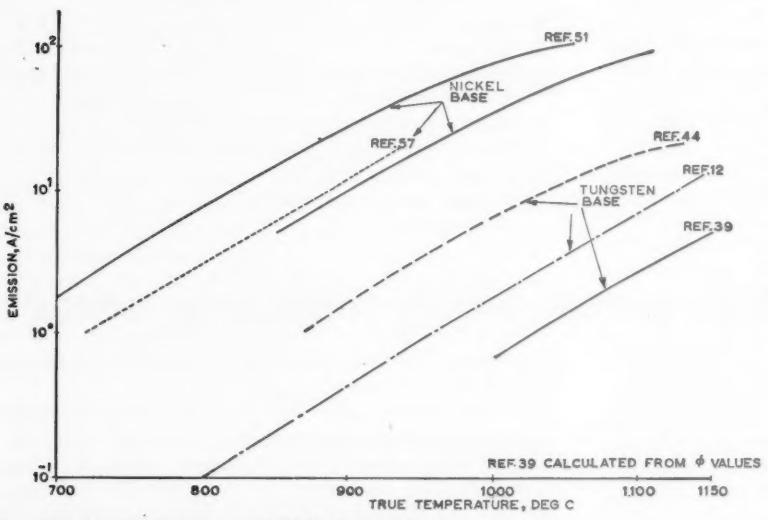
The new cathodes are usually described as 'dispenser cathodes' and have the common feature that the active material is no longer coated on the front of a metallic support.



1 *Some bariated-nickel cathodes*

It is either placed behind a porous metal plate or is incorporated in the material from which the porous plate is fabricated.

Several methods of incorporating the active material are known, but a usual feature is that the chemical reactions consequent on the initial heating of the cathode cause the production of free metallic barium. At the operating temperature the barium is, partly at least, in the gaseous phase, and there is a flow of barium through the pores of the metallic base to the emitting front surface.



2 *Emission for tungsten- and nickel-base cathodes*

The pressure conditions are such that for fine pores, of the order 10μ diameter, as used in practice, Knudsen flow arises, and the pore diameter controls the rate of arrival of barium at the surface. There the barium spreads out over the metal by surface diffusion, and the observed lifetimes are such that more or less complete surface coverage is achieved.

Emission takes place, in this model, from a surface monolayer of barium on the substrate which may be, say, nickel or tungsten. However, other models are possible, and it is necessary to study each type of cathode rather carefully before one can be certain as to the detailed processes occurring. Small changes in technique may provoke first-order changes in, for example, the porosity, which in turn can completely alter the flow conditions.

Nevertheless, several different techniques for the production of successful high-density emitters have now been described. These are discussed in some detail in the paper so that prospective users may evaluate the cathodes, bearing particular requirements in mind.

Comparison between tungsten- and nickel-based cathodes

Broadly speaking, practical cathodes are based on either nickel or tungsten matrices. Available data show that the emission from the nickel systems is measurably better than that from the tungsten; but tungsten can be operated at higher temperatures without excessive evaporation of the base metal. Relevant values are given in Fig. 2. Both types of cathode seem to exhibit pulse emission decay in some circumstances.

Since the lives observed in practice, as mentioned below, seem to depend on heater performance in both cases rather than on cathode operation, the choice must be made on secondary considerations such as manufacturing convenience, cost, ease of processing and freedom from unwanted side effects.

Cathode life

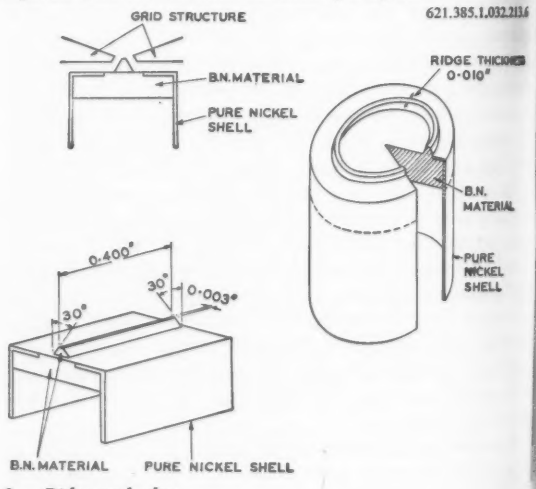
Dispenser cathodes have long lives at high current densities. Using nickel bases, lives of over 20000h at 1A/cm^2 are readily obtained and of 4000–5000h at 4A/cm^2. The life is limited by the heater, which has to operate near the upper limit of the tungsten–alumina system.

Dispenser cathodes are mechanically strong, can be machined to accurate shapes, and are resistant to ion bombardment. They also lend themselves to the fabrication of accurate electron-optical systems. Examples are shown in Fig. 3.

The exploitation of these new cathodes in production tubes is now in its infancy, and it is hoped that this survey will stimulate their intelligent use. Dispenser cathodes will rarely give their best performance if they are merely substituted in guns designed for oxide cathodes.

In particular, new electron-optical systems using the available high emissions should allow advances to be made in precision cathode-ray tubes, storage tubes and the like, where minimum spot size is essential. Finally, it is also possible that the dispenser cathode will contribute to the improvement of special repeater tubes for use where extremely long life is vital.

621.385.1.032.213.6



3 *Ridge cathodes*

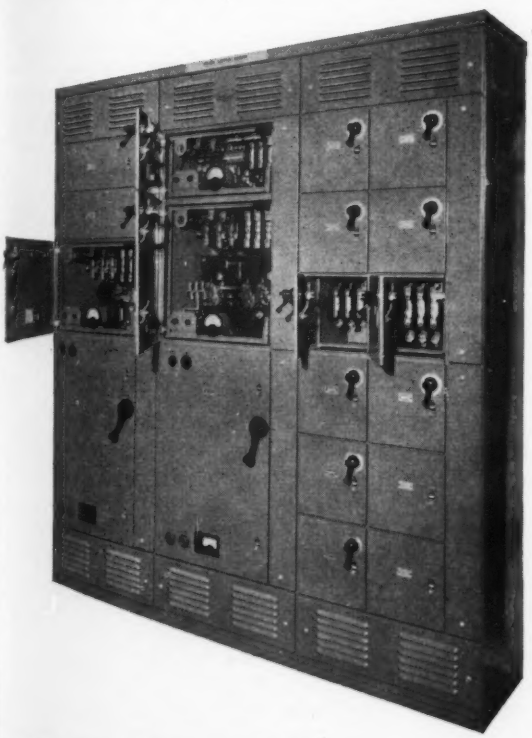
Standardization and simplification of switchgear

A short review of a Graduate and Student Section paper with the above title, by M. J. L. Willison, Graduate. The paper is the Chairman's Address to the South Midland Graduate and Student Section delivered at Birmingham on the 9th October 1957, and it was awarded a Premium by the Council. The author is with the General Electric Co. Ltd.

STANDARDIZATION is the process of defining the functions, quality, dimensions, methods of manufacture and testing of products to ensure that they can be economically reproduced on the basis of the best techniques. Simplification is the process of reducing the number of product types, designs or components within a definite range.

In any organization the number of types of product over a period of time is likely to be large, since free competition tends to multiply variety and because designers by nature and training seek constant improvement in the product. Unless the number of types is frequently reviewed, a selection is made of the most popular and the remainder are discontinued, a manufacturer is soon overwhelmed by the vast range and by enormous stocks of material.

The Anglo-American Council on Productivity report on 'Simplification in industry' states that after visiting the United States they were 'convinced that the reason for high productivity and low cost in America is ruthless elimination of unnecessary variety, and resultant concentration of manufacturing resources'.



1 *Motor control centre for up to 600 volts*

The British switchgear industry needs to lower costs and to shorten delivery times, at the same time maintaining quality and service, and should therefore pay more attention to standardization and simplification.

Advantages

The user can obtain switchgear at lower prices than otherwise possible. Maintenance is easier, the stocks of spares are reduced and an improved service of replacement is obtained.

For the manufacturer, standardization can result in increased manufacturing efficiencies and reduction in stocks. With fewer lines it is possible to concentrate development and research and reduce the technical work required to handle standard orders. There is also a concentration of buying and sales efforts.

Objections

One of the commonest criticisms is that standardization entails rigid uniformity, which clashes with the freedom of action and thought commonly associated with progressive design work.

What is not always realized is that standardization should offer only a temporary lull in the race to improve and that the standard must be revised regularly to keep pace with technical progress. Rigid dimensional standardization should only be employed where both users and manufacturers agree that further development of that particular equipment is likely to be small.

A second criticism is based on the fear that bulk-production methods result in shoddy work. Quality is a question of setting standards and adhering to them by frequent comparison. There is more likelihood of better control and reasonably constant quality with large batches than with small ones.

Standardizing organizations

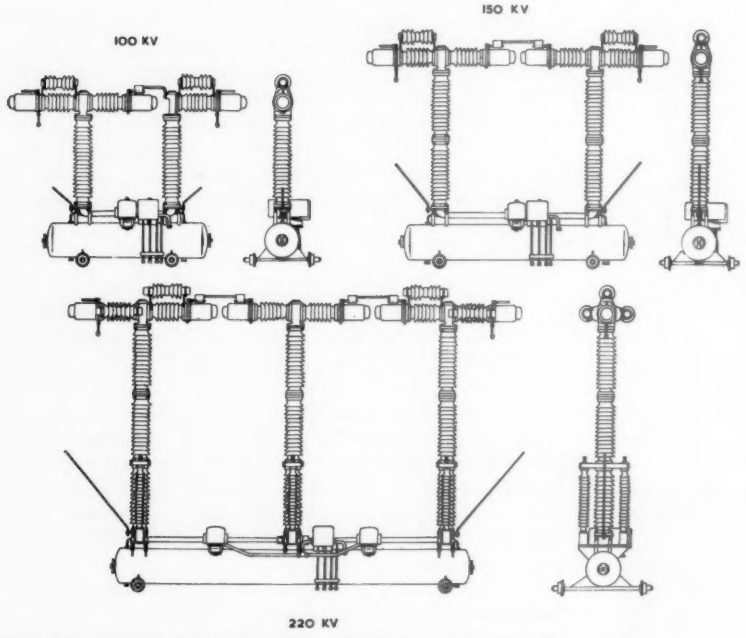
Standardization of users' requirements is a first essential before the manufacturer can make a great deal of standardization progress. Before users and manufacturers meet to discuss details there needs to be a genuine desire to reduce variety and a willingness to make some sacrifices. The standard design must cater for as wide a range of users' requirements as possible without losing the benefits to both user and manufacturer.

The preparation and revision of standards in this country is the work of the British Standards Institution technical committees, on which are represented the users, manufacturers, research associations, Government departments, and professional societies.

In B.S. 116 'Oil circuit-breakers for a.c. systems', there are 164 standard ratings (excluding pole-mounting and flameproof circuit-breakers). It would not help a manufacturer if provision had to be made for them all, and a preferred list of 31 ratings is therefore included to aid simplification.

The nationalization of the electricity supply industry in 1948 merged 561 undertakings into 14 area boards. The wide range of differing voltages and switchgear equipment then in use has since been considerably simplified. The Central Electricity Generating Board and the Area Boards have also established a Joint Switchgear Sub-Committee in collaboration with the Switchgear Section of B.E.A.M.A.

The joint committee has drawn up agreed purchasing specifications to define the Central Electricity Generating Board's requirements, which include: specified protection arrangements; standard connection diagrams and instrument-panel lay-outs; details of operating and isolating mechanisms; and standards for auxiliary equipment. Manufacturers can now start fabrication of certain equipment in batch quantities before receipt of full order details.



2 *Single poles of 100 kV, 150 kV and 220 kV air-blast circuit-breakers*

The International Electrotechnical Commission is the co-ordinating body for all electrical standardization associations, and its purpose is to obtain international agreement on nomenclature, ratings, performance and methods of testing electrical equipment.

Company standardization and simplification

It is not possible in the existing buyers' market for a switchgear manufacturer to lay down inflexible, standard types of equipment which the customer must accept. Provision can be made for a variety of requirements by using standard components—by the modular principle. This calls for an intelligent appraisal of what the user requires, how much in that particular range of switchgear is standard, and what has to be catered for by a range of variables.

Interchangeable construction

Fig. 1 shows a motor control centre designed for up to 600 volts, to accommodate direct-to-line starters from 0 to 100 h.p. in four basic trays. A fifth tray is available for switch-fuse units. The framework is of Meccano-type, bolted construction.

Variations in cubicle height, depth and width and modifications to the trays can be obtained while still using standard components and manufacturing tools. This interchangeability is the secret of successful standardization: it avoids excessive rigidity and allows for likely variations required by the customer.

Fig. 2 shows the single poles of 100 kV, 150 kV, and 220 kV air-blast circuit-breakers which use the same arc-extinction chambers and capacitors across the breaks. Standard hollow porcelain insulators and components are used throughout the range 80–400 kV, the latter having ten arc chambers in series per pole. For higher breaking capacities the circuit-breakers are modified by the addition of standard auxiliary contacts and resistors. The main blast valves and the electro-pneumatic control units are identical.

Design-office standardization

Even when most orders vary in some details, there is usually a certain amount of repeatable basic information to be handled which can often be preprinted to save drafting time. For standard designs, the issuing of instructions to the manufacturing departments can usually be done by clerks under supervision of a draughtsman.

Company standardization, to be effective, should be co-ordinated by a standards department, who will draw up and constantly review the company standards. These should relate to national standards wherever possible and be indexed. Unless it is simple to find standard components already in existence, it is easier to design a new component.

Conclusion

To be acceptable, a standard must suit the user's needs and be practicable for the manufacturer. It should result in a considerable saving for both of them. It should not lag far behind development and should never be regarded as static but rather as a record of the best methods at the time of publication. Revision should be prompt if a better method is discovered. Acceptance of a standard is most complete when all interested parties have helped to produce it.

New mental outlooks are required from engineers at all levels, who should develop a desire to reduce unnecessary and wasteful variety.

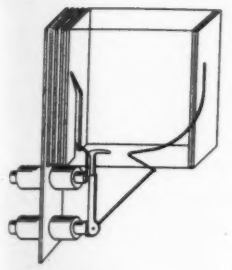
The need for more standardization and simplification, and hence greater output with available manpower, has become of prime importance in oversea trade. 621.316.57:389.6

H.V. circuit-breakers with insulated-steel-plate arc chutes

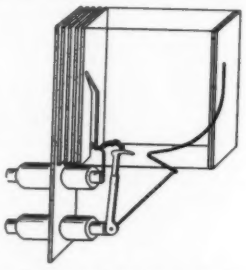
A short review of a Supply Section paper (2746) entitled 'Development of high-voltage air-break circuit-breakers with insulated-steel-plate arc chutes', by F. S. Fay, M.A., Associate Member, J. A. Thomas, B.Sc., Associate Member, D. Legg, B.Sc., Graduate, and J. S. Morton, B.Sc., Associate Member. The paper was published individually in November 1958 and will be republished in Part A of the Proceedings. The authors are with A. Reyrolle and Co. Ltd.

IN an air-break circuit-breaker, arc extension is achieved by drawing the arc inside an arc chute, which confines the arc and raises its resistance so that the current cannot be maintained by the circuit voltage. The resistance of the arc begins to increase immediately the circuit-breaker contacts separate, the subsequent build-up of arc resistance being effected by the lengthening and cooling of the arc.

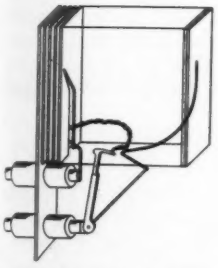
The resistance of the arc is roughly proportional to the length of the arc path, and arc extinction is more easily and effectively achieved by lengthening rather than by intensive cooling. To obtain the required arc length at high voltages in the most economical space, the arc is forced into a compact zig-zag path formed by slotted refractory arc-chute plates (Fig. 1). To do this as quickly as possible, the natural electromagnetic and thermal forces are supplemented by a strong magnetic field, which acts along the length of the arc and is produced by slotted magnetic plates. The action of a magnetic plate is to move the arc towards the closed end of the slot (Fig. 2).



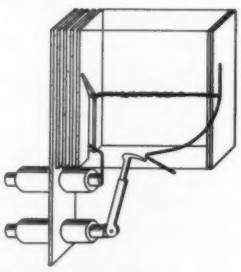
1 Contacts closed



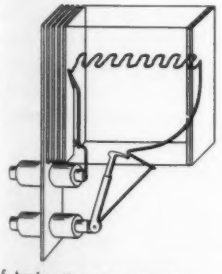
2 Contacts opening and drawing an arc



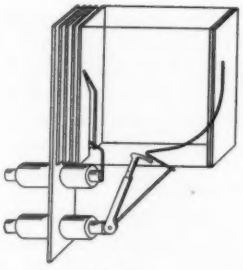
3 Arc being transferred from the moving contact



4 Arc moving up the chute

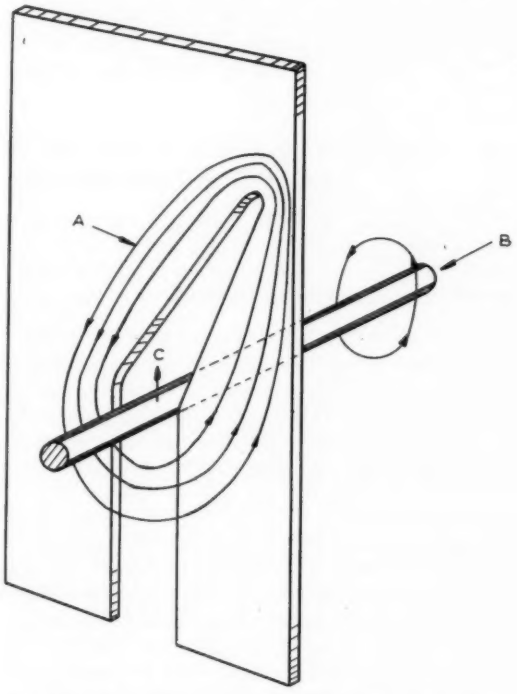


5 Arc lengthened in the chute



6 Arc extinguished

1 *Model illustrating arc extinction in an air-break circuit-breaker*

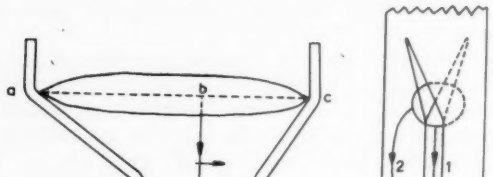


2 *Effect of a slotted magnetic plate on the arc column*
A Lines of magnetic flux in the iron
B Direction of current flow
C Direction of the force on the arc column

Practical development

The practical development of this principle was the insulated-steel-plate arc chute, in which the magnetic material in the form of a series of spaced steel plates is placed inside the arc-chute box and insulated by embedding the steel in plates of moulded mica and glass. By

arranging the arcing contacts to initiate the arc between the plate legs, the supplementary magnetic field is established before the arc is drawn.



3 *Initiation of a downstrike to the moving contact*

While the arc is being lengthened, the magnetic field acts not only on the portions of the arc that lie in the slots but also on those that lie parallel to the plane of the plates. This construction makes the use of a blow-out coil, with its inherent switching-in delay, unnecessary.

High-speed photography

High-speed photography played an important part in the development of the arc chute and has enabled many improvements to be made. For example, random failure of arc chutes at the higher currents and voltages indicated a weakness in the earlier arc-chute designs. This resulted in a photographic examination at framing rates up to 500 000 frames/sec of the formation of new arc cores.

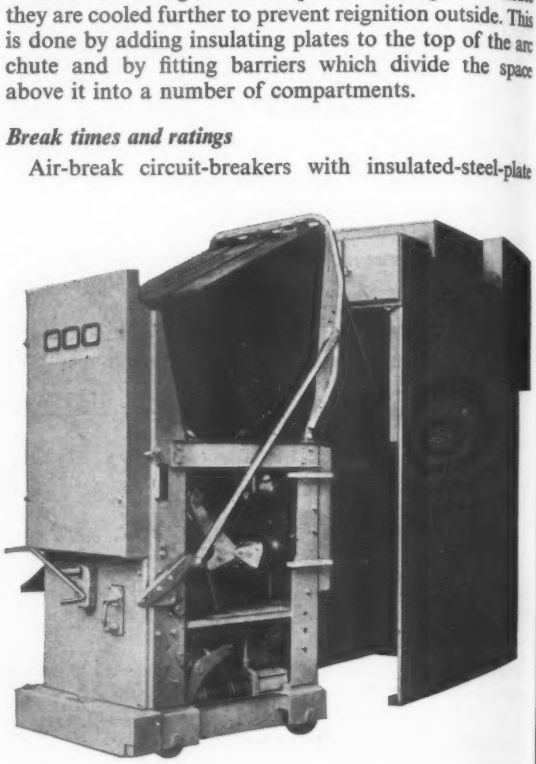
It was found that branches of the arc core were formed vertically downwards and could be established between the legs of adjacent plates and locked there, pressed against the side wall of the chute, for several milliseconds, during which only part of the chute was employed effectively. In this time the lower part of the arc loop (x, y in Fig. 3) could move further down under the action of its own electromagnetic loop force, forming an uncontrolled arc below the arc chute.

The curing of this trouble by the partial blocking of the space between chute-plate legs has been one of the major factors in giving consistency of results. Small gaps prevent a continuous conducting path being formed across the chute owing to deposited copper vapour. With this construction, downstrikes do not occur between the legs of adjacent plates, and there is no tendency for the arc to spread below the chute. Downstrikes can only form down the 'tunnel' (path 1, Fig. 3) and are forced back into the middle zone of the chute by the electromagnetic forces, in times of the order of several hundred microseconds.

After the arc gases have passed through the chute they are cooled further to prevent reignition outside. This is done by adding insulating plates to the top of the arc chute and by fitting barriers which divide the space above it into a number of compartments.

Break times and ratings

Air-break circuit-breakers with insulated-steel-plate arc chutes have total break times of the order of 3 cycles over the short-circuit range, rising to 6 cycles at low currents. No appreciable transient voltage is produced when switching magnetizing currents and capacitive currents.



4 *11kV 500MVA air-break circuit-breaker, with arc chutes raised and barriers removed*

Voltage/current curves showing limits of performance of the insulated-steel-plate arc chute have formed the basis for choosing various arc-chute sizes. These have led to the production of circuit-breakers having ratings of 500MVA at 11kV and 750MVA at 15kV (Fig. 4) and have also been used to predict arc-chute performance at up to 33kV with considerable accuracy.

Conclusions

The research has shown that air-break circuit-breakers with insulated-steel-plate arc chutes are eminently suitable for high voltages. Meticulous attention to arc control has made the circuit-breakers very reliable, and their performance sets a new standard for air-break circuit-breakers in Great Britain.

621.316.57

The following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available shortly.

Accurate measurement of g_m

A synopsis of an Electronics and Communications Section paper (2832) entitled 'A method for the accurate measurement of mutual conductance of thermionic valves', by M. R. Child, Associate Member, and D. J. Sargent, B.Sc. The paper is published this month in Part B of the Proceedings. The authors are at the Post Office Research Station.

The paper mentions briefly the need for measuring accurately the mutual conductance of thermionic valves at various intervals and explains in some detail how this measurement can be undertaken. It is difficult to assess the precise magnitude of the errors involved, but, while the inaccuracy in the absolute value of mutual conductance may be as great as 0·25%, it is unlikely that the errors in comparative measurements will exceed 0·1%.

The method described is readily adaptable for the measurement of anode conductance and screen-grid amplification factor. 621.317.61 : 621.385.1

Perturbation method for circular waveguides containing ferrites

A synopsis of an Electronics and Communications Section paper (2796) with the above title, by P. J. B. Clarricoats, B.Sc.(Eng.), Ph.D., Graduate. The paper is published this month in Part B of the Proceedings. Dr. Clarricoats is in the Department of Light Electrical Engineering, Queen's University of Belfast, and was formerly with the General Electric Co. Ltd., Stanmore.

The author describes a perturbation method which enables the propagation coefficient of a circular waveguide, containing a longitudinally magnetized ferrite, to be determined over a wider range of parameters than hitherto. The method relies on the fact that, when a mode, propagating in a circular waveguide containing a longitudinally magnetized ferrite rod, is circularly polarized on the waveguide axis, the field throughout the whole of the ferrite is nearly circularly polarized.

Theoretical and experimental results for the negative circularly polarized dominant mode are favourably compared in the case of a Ferroxcube B2 ferrite. 621.317.34 : 621.372.85

Directive aerials in complex u.h.f. fields

A synopsis of an Electronics and Communications Section paper (2807) entitled 'The performance of directive aerials in complex u.h.f. fields', by J. A. Saxton, D.Sc., Ph.D., Member, and B. N. Harden, M.Sc. The paper is published this month in Part B of the Proceedings. The authors are at the Radio Research Station.

The paper describes an investigation, at frequencies of 580 and 904 Mc/s, of the apparent gains relative to a half-wavelength dipole of a number of directive aerials at a typical selection of receiving sites in urban and in rural areas.

It is shown that variations of the apparent gains occur, as a result of the complexity of the radio field patterns generally found at such sites, to an extent which may be significant in the estimation of the coverage of transmitters operating in the broadcasting bands IV and V. 621.396.677

Transistors and associated semiconductor devices

A synopsis of a review of progress (paper 2914) with the above title, by R. G. Hibberd, B.Sc., Associate Member. The paper is published this month in Part B of the Proceedings. The author is with the British Thomson-Houston Co. Ltd.

After a brief introduction, some statistics on the growth of the semiconductor industry since 1948 are quoted. Mention of the main operations involved in the processing of germanium and silicon is followed by a general discussion of semiconductor-device technology, including *p–n* junction formation and other aspects of device manufacture. Reference is made to publications on various aspects of semiconductor-device theory, and there follows a detailed account of the types and characteristics of the various semiconductor devices now commercially available, including diodes and rectifiers, junction transistors and photo-electric devices. Finally, brief mention is made of the main fields of application of diodes and transistors. 621.382

Measurements from U.S.S.R. earth satellites

A synopsis of an Electronics and Communications Section paper (2963) entitled 'Observations on the U.S.S.R. earth satellites and the study of radio-wave propagation', by W. C. Bain, M.A., B.Sc., Ph.D., and E. D. R. Shearman, B.Sc.(Eng.), Associate Member. The paper is published this month in Part B of the Proceedings. The authors are at the Radio Research Station.

Measurements of bearing, angle of elevation and Doppler frequency shift have been performed at Slough on transmissions from the Russian earth satellites. The examples considered here indicate that the observed phenomena can be accounted for satisfactorily in terms of our present knowledge of ionospheric propagation. A short section is included on orbital determination from the measurements.

621.396.946 : 621.396.8

Hemi-isotropic radiators for the S- or X-band

A synopsis of an Electronics and Communications Section paper (2849) with the above title, by E. G. A. Goodall, M.Sc. The paper is published this month in Part B of the Proceedings. The author is at the Research Laboratories of Marconi's Wireless Telegraph Co. Ltd.

An aerial having approximate hemi-isotropic properties has been constructed on the principle that a dielectric rod will act as a guiding medium for electromagnetic energy. Using this principle, a broadband, shaped dielectric element has been developed, which, when placed at the aperture of an open-ended circular waveguide, radiates with hemi-isotropic cover over a 20% frequency band. 621.396.67

Integrally constructed waveguide assemblies

A synopsis of an Electronics and Communications Section paper (2852) entitled 'The design and testing of integrally constructed waveguide assemblies', by G. Craven and V. H. Knight. The paper is published this month in Part B of the Proceedings. The authors are with Standard Telecommunication Laboratories Ltd.

Problems associated with integrally constructed waveguide assemblies are discussed and the advantages of this form of construction shown: suitable components and methods of construction are described. Complex assemblies of this type present special testing problems which are solved by employing a plug-in reflectometer, together with a swept-frequency reflection display. These principles are applied to a typical microwave link repeater, and the alignment of the signal-input section is described in detail. An over-all performance with less than 2% reflection is confirmed by independent measurement. 621.372.8:621.317.34

Current gain of plane-alloy-junction transistors

A synopsis of an Electronics and Communications Section paper (2855) entitled 'An investigation of the dependence of the current gain of a plane-alloy-junction transistor on emitter current and frequency', by F. J. Hyde, M.Sc., Associate Member. The paper will be published in Part B of the Proceedings. The author is now in the Department of Electronic Engineering, University College of North Wales.

The complex internal current gain α_d of a diffusion-type germanium transistor has been derived from measurements of the external short-circuit current gain α at frequencies up to 20 Mc/s and for emitter currents between 15 μA and 3 mA by taking account of the effects of the emitter and collector depletion-layer capacitances and the ohmic base resistance. The resulting frequency-dependence of α_d is that expected from one-dimensional diffusion theory. At low emitter currents, the flow of r.f. current in the emitter depletion-layer capacitance causes the cut-off frequency of α to be less than one-third that of α_2. 621.382:621.317.61

Current gain of drift transistors

A synopsis of an Electronics and Communications Section paper (2856) entitled 'An investigation of the current gain of a drift transistor at frequencies up to 105 Mc/s', by F. J. Hyde, M.Sc., Associate Member. The paper will be published in Part B of the Proceedings.

The complex internal short-circuit current gain α_d of a type-2N247 plane-alloy-junction germanium transistor has been determined from measurements of the external short-circuit current gain by taking account of the effects of the emitter and collector depletion-layer capacitances and the ohmic base resistance. Measurements have been made up to 105 Mc/s and over a range of emitter current from 50 μA to 8 mA. 621.382:621.317.61

H.F. power gain of drift transistors

A synopsis of an Electronics and Communications Section paper (2857) entitled 'High-frequency power gain of the drift transistors', by F. J. Hyde, M.Sc., Associate Member. The paper will be published in Part B of the Proceedings.

Approximate expressions are derived for (a) the critical frequency above which the ideal transistor is unconditionally stable, and (b) the resulting maximum available gain, for the common-emitter configuration. These involve the internal cut-off frequency, the low-frequency emitter input conductance, the ohmic base resistance and the emitter and collector depletion-layer capacitances. 621.382:621.372.5

Phase measurements through tapered junctions

A synopsis of an Electronics and Communications Section paper (2854) with the above title, by L. Lewin, Associate Member. The paper will be published in Part B of the Proceedings. The author is with Standard Telecommunication Laboratories Ltd.

If a tapered section is suitably matched at the transitions between two uniform waveguides, the electrical length of the taper is usually taken to be its physical length. It is shown here that a small correction is necessary on account of the cylindrical nature of the wave which propagates in the taper region, and a simple expression for the correction is found for a rectangular waveguide in the dominant mode.

621.372.822:621.317.373

THE VELOCITY OF PROPAGATION OF ELECTRICAL BREAKDOWN IN A GAS

THE velocity of propagation of the electrical-breakdown process in a gas is important for its own sake. On the writer's view[1a] that many astrophysical phenomena can be explained in terms of the electrical breakdown of pre-existing *electrostatic* fields in cosmical atmospheres, the velocity of propagation assumes a new significance, in that it determines the time scale of many of these phenomena.

The following evidence, based on phenomena which the writer regards as electrical discharges in the terrestrial, solar, stellar, and galactic atmospheres, suggests that the velocity of propagation is uniform and equal to 10^7–10^8 cm/s over a range of about 10^{20} to 1 in gas density, as theory suggests it should be. The mean free paths involved range from a millionth of a centimetre in the laboratory discharges to 1000 million kilometres in galactic atmospheres.

The laboratory data as summarized by Allibone and Meek[2] are compatible with Schonland's[3a] better-established average value of about 2×10^7 cm/s for the leader stroke of the lightning discharge in air at atmospheric pressure. This value should theoretically be independent of the gas density[3b], at least to a first approximation. Cosmical discharges occur in a hydrogen atmosphere, but Allibone[4] has found some evidence that the velocity of propagation in laboratory discharges in hydrogen is only slightly greater than in air.

The first of the available extra-terrestrial estimates is obtained on the theory[1a] that those magnetic storms which follow solar disturbances by periods of about a day are the result of electrical discharges propagated outwards past the earth in the solar atmosphere. These time intervals, one to four days,[5] together with the earth's distance from the sun, yield velocities of about 4×10^7 to 2×10^8 cm/s.

The next estimate is obtained from the discharge theory of the long-period variable stars[1b, c]. Their atmospheres extend to heights of 10^{14}–10^{15} cm above their 'surfaces'; and the periods during which bright emission lines appear in their spectra, denoting the propagation of the discharges, are of the order of 10^7–10^8 sec. These distances and times again lead to average velocities of the order of 10^7–10^8 cm/s for the velocity of propagation.

The third extra-terrestrial estimate is derived from the intensity of the radio-emission from NGC 4486 (in which, on the electrical-discharge theory of galactic evolution, [1a, e] the discharge is occurring) in relation to the total of metagalactic radio noise. Shklovsky[6] has shown that the comparison indicates that, if the latter is to be explained as deriving from similarly 'discharging' galaxies, these last must represent 1% of the total population of extragalactic nebulae. From this we deduce that the discharge phase occupies about 1% of the galaxy's lifetime.

Since the total age of the galaxies is 10^9–10^{10} years, the discharge process must therefore last for 10^7–10^8 years in any one nebula. Since the total length of these discharges—the length of the spiral arms—is 10^4–10^5 light-years, it follows that the velocity of propagation of the breakdown process is about 10^{-3} times the velocity of light, or again 10^7–10^8 cm/s.

As well as supporting the theoretical conclusion that this velocity of propagation should be independent of the density, the uniformity of these results conversely affords further support for the general theory that all these phenomena can be accounted for in terms of the breakdown of electric fields. These are gradually built up in these cosmical atmospheres, probably by a process of static electrification similar to that occurring in terrestrial sand and dust and thunderstorms.

C. E. R. BRUCE, M.A., D.SC., MEMBER
The Electrical Research Association Laboratory,
Cleeve Road,
Leatherhead, Surrey

3rd April 1959

1 BRUCE, C. E. R.: (a) 'A new approach in astrophysics and cosmogony' (London, **1944**); (b) *Observatory*, 1955, **75**, p. 82; (c) *Philosophical Magazine*, 1955, **46**, p. 1123; (d) *Philosophical Magazine*, 1958, **3**, pp. 539, 1328; (e) 'Evolution of extragalactic nebulae and the origin of metagalactic radio noise', *E.R.A. Report* **Z/T117**, 1958
2 ALLIBONE, T. E., and MEEK, J. M.: *Proceedings of the Royal Society A*, 1938, **166**, p. 97
3 SCHONLAND, B. F. J.: (a) 'Atmospheric electricity' (Methuen: **1953**), p. 71 and Fig. 16; (b) *Proceedings of the Royal Society A*, 1938, **164**, p. 132
4 ALLIBONE, T. E.: Private communication
5 CHAPMAN, S.: 'The earth's magnetism' (Methuen: **1951**), p. 115
6 SHKLOVSKY, I. S.: *Proceedings of the International Astronomical Union*, 1956, Paper No. 36 (Cambridge University Press: **1957**, p. 205)

THE JUNCTION TRANSISTOR AND ITS APPLICATION

MR. Robert Wells's hydraulic analogy (March *Journal*, p. 170) would give a very misleading picture of conduction in *p*-type semiconductor. In fact, Mr. Wells appears to have been misled by it himself in stating that in such material there can be 'only a flow [of current] due to thermally excited minority carriers'.

If one has to use a hydraulic analogy, a more helpful one represents a piece of *n*-type material in a circuit by a vertical section of empty pipe, separated at top and bottom from the rest of the system full of water by a porous septum, through which water can flow only in drops. These, falling through the section, denote the few free electrons made available by the relatively very few impurity atoms present. The pressure of the pump would, of course, come almost entirely across this section, very little being needed to keep the water flowing at such a slow rate through the open piping.

On the same basis, *p*-type material has to be represented by a section *filled* with water, except for a few vacuous bubbles, continually created by the low pressure at the bottom septum, rising through the section and being extinguished at the top septum by drops of water forced through it by the high pressure.

Intrinsic conduction is neglected in both cases.

Mr. Wells's closed rings of semiconductor can be portrayed (for *n*-type) by an annular tunnel with a few people running

through it in circles and (for *p*-type) by the same tunnel jammed so tightly with people that they can only move at all by stepping forward successively into the few empty spaces. These spaces, otherwise the holes, obviously move in the opposite rotation (i.e. the conventional direction of the electric current represented).

M. G. SCROGGIE, B.SC., MEMBER
18 Bromley Common,
23rd March 1959 Bromley, Kent

WHAT IS NEGATIVE IMPEDANCE?

MR. M. O. Williams has pointed out (March *Journal*, p. 169) that the British Standards Institution, supported, he believes, by The Institution, has pronounced that impedance is the ratio of the r.m.s. electromotive force in the circuit to the r.m.s. current which is produced thereby, and that it should be denoted by the symbol *Z*.

The Concise Oxford Dictionary defines 'ratio' as the quantitative relation between two similar magnitudes determined by the number of times one contains the other integrally or fractionally.

As I have pointed out elsewhere, the use of the word ratio in the sense in which it is used by the B.S.I., as opposed to the dictionary, is a reasonable mathematical extension of the common meaning of the word if it serves a useful purpose. But that is hardly the case here. Impedance means far more than the quoted definition would suggest; this definition is only applicable in a very limited part of even the electrical field.

Impedance is one example of a transform (sometimes inaptly called a transfer function); it is an 'operator'—a term which has been in common and continuous use since long before either Institution was thought of. It is not a ratio in the dictionary sense. It is defined by the equation:

$$V = ZI$$

From this equation all limited definitions derive. In a simple *LCR* circuit, $Z = Lp + R + Q/C$; in other cases, explicit expression may be impossible.

With Mr. Williams I have an instinctive dislike of the term 'negative impedance'. Yet it has its convenience. One may ask a colleague to make a circuit non-reactive at all frequencies by inserting a 'negative inductance'. It saves a lot of words when one knows that the person addressed understands exactly what one means. Moreover, the meaning of no word in common use, such as ratio, is distorted.

A. G. WARREN, MEMBER
24th March 1959 Ministry of Supply

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

JAMES ATKINSON

James Atkinson, who was born at Preston on the 15th April 1909, died suddenly at his home in Hayes, Kent, on the 17th January 1959. He was educated at Preston Grammar School and later at Preston Technical School.

In 1925 he entered the Post Office as a 'youth-in-training', studying part-time at the Northampton Polytechnic. After six years' service in Preston, Blackburn and the circuit laboratory of the engineer-in-chief's office, London, he was appointed to the grade of inspector in 1931 and to that of assistant engineer in 1932.

During the period 1931 to 1939, he was employed on the design and specification of automatic telephone exchanges and thus contributed to much of the pioneer work in that field in the United Kingdom. It was during this period that the Post Office standardized on the Strowger automatic step-by-step system, in which he became a recognized expert.

Before the 1939–45 War, the Post Office was adopting a regionalized organization, and after a brief spell in the newly formed north-western region headquarters at Manchester he was appointed area engineer at Edinburgh, where he remained until 1949 and during the war years was engaged on the provision and maintenance of defence communication.

In 1949 he returned to the engineer-in-chief's office as executive engineer. For just over one year from 1950 he was seconded to the Telephone Manufacturing Co., Dulwich, to assist in the furtherance of export business. On return to the Post Office, he was again employed on the design and provision of automatic-telephone-exchange systems and was promoted to assistant staff engineer in 1953. In 1956 he was lent to the Nigerian Post and Telegraph Department, to prepare a basic plan for the progressive modernization of the Nigerian telephone system, with the ultimate objective of automatic subscriber dialling.

He was a man of exceptional energy and versatility and possessed a specialized knowledge of telephone-exchange operation that few could equal. His premature death was a heavy loss to the Post Office and to his wide circle of friends in the telephone world, in this country and oversea. Much of his knowledge of telephone-exchange practices, acquired during his 30 years' service, is recorded in the two volumes of 'Telephony' which were published during the period 1948–52.

Atkinson was a man who carried his vitality equally into his private life as in his official career, and he was never happy unless engaged in his home or garden or in his particular hobby, photography. He is survived by his widow and a son.

He joined The Institution as a Student in 1934 and was elected an Associate Member in 1936 and a Member in 1950. W. A. H.

WILFRED ARTHUR ERLEBACH

Wilfred Arthur Erlebach, B.SC.(ENG.), who was born in London of West Country stock on the 17th December 1881, died on the 3rd November 1958. He was educated at Woodford House School, Birchington, at Düsseldorf and at Liège University. He returned to London to study at University College, being awarded the degree of B.Sc.(Eng.) in 1905. He received practical experience with C. A. Parsons and Co., Newcastle, and the British Westinghouse Electric and Manufacturing Co. Ltd., Manchester, before joining Johnson and Phillips Ltd., Charlton, as chief electrical designer in 1909.

In 1911 he became an estimating and contract engineer with Siemens Brothers (Dynamo Works) Ltd. until 1926. For a while he had one or two posts in various firms until, in 1929, he joined the technical staff of Carpmaels and Ransford, where he remained until his death. He proceeded forthwith to study for the examinations

of the Chartered Institute of Patent Agents, qualifying in 1934 and being elected a Fellow shortly afterwards.

He was a devout Christian and worked constantly in the Congregational and later in the Methodist Church. His hobbies were mostly out of doors, except for the study of electrical science, to which he devoted much of his spare time. He was a keen gardener and loved walking in the country, covering many miles in England and Ireland; he was also a fine swimmer. He became a Freemason later in life and regularly attended the meetings of the Craft. He is survived by his widow, four children and a number of grandchildren.

Erlebach joined The Institution as an Associate Member in 1925 and was elected a Member in 1926. R. E.

JOHN MASSEY MORRIS

John Massey Morris, O.B.E., who was born on the 10th January 1884, died on the 2nd February 1959. He was educated at Manchester Grammar School and, following his apprenticeship with Mather and Platt Ltd., spent the nine years immediately preceding the First World War on general engineering work in Canada. On the outbreak of war he immediately joined the Forces and served in German East Africa and North Russia before being seconded, in 1919, to the Royal Engineers in Mesopotamia. He was commissioned in the field in 1917 and was mentioned in dispatches.

He was responsible for the first installation of electrical plant in the Basra area at Ashar, which was at that time supplying military installations only. Three years later he was transferred to the Royal Air Force works and buildings section, which by that time had become responsible for electricity supply to Service installations in the area. Ten years later, in 1932, the public supply of electricity became the responsibility of the Basra Port Directorate, which was also the authority responsible for water supplies in the Basra area, and Morris joined the directorate as its engineer in charge of water and electricity supplies. From that date he remained responsible for these services and saw the electrical undertaking grow until the maximum demand exceeded some 10 MW.

Outside his work, he took an active interest in the life of the British community in Basra and was chairman of the British Council centre in Basra from 1946 until his death. He was a keen amateur-theatrical producer. He was also responsible for the formation of the Joint Group of the Institutions in the 'Iraq and Persian Gulf area and was chairman of the Group during 1957–58.

It was almost impossible to be in Basra for more than a day or two without meeting Morris, and many visitors will remember gratefully his hospitality and sound advice. He is survived by his widow and a daughter.

He joined The Institution as an Associate Member in 1941 and was elected a Member in 1953. He served as Oversea Representative of the Council for the Middle East from 1952 to 1959. He was appointed a Member of the Order of the British Empire in 1946 and an Officer of the Order in 1953. J. F. ST.G. S.

WILLIAM JAMES PICKEN

William James Picken, O.B.E., who was born on the 11th October 1886, died on the 24th February 1959, after being in ill-health for some months. He received his technical education part-time at Southend Technical School, Chelmsford Technical Institute and Manchester Technological Institute. He served an apprenticeship with Crompton and Co. Ltd., Chelmsford, from 1905 to 1908 and during the following five years was employed by the company as a contract engineer.

In 1913 he joined Marconi's Wireless Telegraph Co. Ltd. and carried out installation work in connection with their transatlantic stations at Clifden, Ireland, and at New Brunswick, U.S.A. From 1914 to 1918 he was engaged with Capt. H. J. Round of Marconi's on direction-finding and the interception network for the anti-U-boat operations around the coast. In 1919 he joined the research staff of the company, under Round, and was engaged on valve-development work. In 1928 he was appointed valve controller and, in 1935, deputy engineer-in-chief. He later became engineer-in-chief, a position with which he combined that of general manager from 1938 to 1940.

In 1941 he visited Canada and America for liaison purposes in connection with war-time developments in the valve field. In 1943, after returning to this country, he was seconded to the Department of Scientific Research and Experiment, Admiralty, at the latter's request. Here he worked with Dr. H. J. E. Griffiths in C.V.D.—the department responsible for the development of all valves for defence purposes. In 1946 he left Marconi's and succeeded Griffiths as secretary to C.V.D., a post which he held until he retired from the Admiralty in 1953, when he was honoured at a dinner attended by many people in the valve world with whom he had been associated.

After a short period of retirement, he joined the English Electric Valve Co. Ltd. in 1953 as technical consultant, dealing mainly with the recruitment of new staff.

He was for many years a member of the Technical Committee of the British Valve Manufacturers' Association.

Picken was a keen golfer, a sport which he was able to enjoy until nearly the end of his life. He will be remembered for his kindly and helpful ways and for the care and attention which he gave to the problems of the younger men. He is survived by his widow.

He joined The Institution as an Associate Member in 1927 and was elected a Member in 1935. He served on the Wireless Section Committee from 1937 to 1940, being chairman in 1940–41. His paper entitled 'Cooled-anode valves, and valve lives' was published in the *Journal* in 1927. He was appointed an Officer of the Order of the British Empire in 1950. A. J. Y.

VADAMALAI SESHASAYEE

Vadamalai Seshasayee, who died suddenly at his home at Tiruchirapalli, South India, on the 19th October 1958, was born on the 14th August 1890. He was educated at St. Joseph's College, Tiruchirapalli. His first appointment was as electrician on the South Indian Railway.

From 1908 to 1933 he was in partnership with his brother, the late R. Seshasayee, an American-trained engineer, setting up business as Seshasayee Brothers Ltd., destined to become managing agents of great repute. Their early works were the electrification with oil-engine plant of some famous temples in South India. In 1925 the firm obtained from the Government of Madras a licence for the supply of electricity to Tiruchirapalli and the neighbouring Srirangam. This was followed, eight years later, by another licence to supply electricity to the East Tanjore district and, four years later, by a further licence for the East Ramnad district.

By 1935 the Government had established its extensive hydro-electric Grid supply and so enabled the Tiruchirapalli–Srirangam area to be changed over from oil-engine energy, also providing the energy for the two other licence districts. The combined area of these three contiguous regions, merged in 1940 into the South Madras Electric Supply Corporation, was 12000 square miles.

Seshasayee was not content with electricity supply alone; his firm became the managing agents of three chemical works, and in the last few years of his life he was interested in the immense Neiveli peat project and initiated therein an h.v. insulator factory and an engineering works.

He was an outstandingly kind employer and was interested in technical education—he founded a college in Tiruchirapalli for this purpose. He was of a pious and philanthropic disposition, a keen bridge-player, and a sound scholar of Sanskrit and Tamil. He is survived by his widow, a daughter and three sons. He joined The Institution as a Companion in 1937. E. J. B. G.

GEORGE RITCHIE CROLL SOUTAR

George Ritchie Croll Soutar, B.Sc., who was born on the 5th November 1897, died at Camserney, Perthshire, early in 1959. His education at the High School, Dundee, was interrupted by the First World War, during which he served in the Royal Naval Volunteer Reserve in minesweepers and later in the R.A.F.

Resuming his studies after the war, at University College, Dundee, he graduated with a B.Sc.(Hons.) degree and joined the General Electric Co., specializing in the design of telephone equipment. In 1931 he entered the Admiralty service as a senior technical officer and joined the department of torpedoes and mining. The department was at that time responsible for the design of electrical equipment for the control of armament and for communication in naval vessels. In 1939 this responsibility was transferred to the electrical engineering department, and Soutar continued his work in that department, making notable contributions to communication systems in ships during the Second World War.

In 1948 he was promoted to senior principal scientific officer and appointed to the Admiralty Torpedo Experimental Establishment, Greenock, as head of the civilian development and design staff in that establishment. He was promoted to deputy chief scientific officer in 1951, continuing to serve at Greenock, and retired in 1958 because of ill-health.

He played golf and was a keen and very skilled motorist. He is survived by his widow and a married daughter, who, before marriage, qualified in medicine at his old university.

He joined The Institution as a Member in 1956. H. S.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report C/T117 **Development of a method for measurement of strains in the blades of a windmill rotor** by J. G. Morrison. 24s. (postage 6d.)

THE report describes a technique for measuring, by means of electrical-resistance strain gauges, the strains set up in the rotor blades of a windmill driving an electric generator. The strain-gauge elements are described, and details are given of the amplifying and recording equipment and of the steps taken to ensure synchronization between the recordings of generator power output, wind speed and strain.

Report G/XT164 **Radiation losses from the arc column** by H. Pelzer 15s. (postage 6d.)

EXISTING theoretical work on the radiation from high-current arcs is summarized. Some earlier results are found to be in error and are corrected. An estimate is obtained of the total energy loss due to radiation in the temperature range 10000°–35000°K, which amounts to about one-quarter of the loss due to conduction discussed in Report G/XT155 (March 1959 *Journal*, p. 175).

Report L/T362 **Stability, reignition time and other features of the cold arc** by A. E. Robson 6s. (postage 4d.)

THE work described in Reports L/T330 and 331 (June 1958 *Journal*, p. 330) is continued here. A qualitative method of calculating the equilibrium current density is given, showing the importance of oxide layers on the cathode. The occurrence of cold arcs on refractory cathodes is discussed.

Report L/T377 **Effects of irradiation on the dielectric properties of polythene** by E. Rushton 10s. 6d. (postage 6d.)

THE effects of neutron and electron irradiation on the dielectric properties of polythene are described. Samples of ordinary polythene, prepared at relatively high temperatures and pressures, and of the new high-density polythenes, prepared at relatively low temperatures and pressures, were examined. Dosages up to about 10^7 rads have little effect on the dielectric properties of ordinary polythene; but above that the loss tangent increases and the larger the dosage the greater the increase in loss tangent.

Report V/T138 **Does stray alternating current corrode water systems? Investigation of installation at Rochdale** by G. Mole and D. P. Hammond 15s. (postage 6d.)

THE construction in 1956 of a large 275kV/132kV substation close to a water reservoir and filter station having extensive underground mains provided the opportunity to study the effect of stray alternating current on the rate of corrosion of water mains.

The measured direct potential of the water mains with respect to earth was taken as the criterion rate. Alternating current was injected into an isolated length of underground main. Induction from overhead lines was simulated by inducing alternating current in undisturbed mains.

BRITISH STANDARDS INSTITUTION

B.S. 1000B: 1958 (F.I.D. no. 277) **Universal decimal classification. Trilingual (abridged) edition** £6 6s.

THIS trilingual edition, with its outline of U.D.C. schedules corresponding closely to B.S. 1000A and other national abridged editions and its alphabetical keys in German and French, is regarded as the international standard U.D.C. abridgement.

B.S. 1933: Part 3: 1959 **Varnish-bonded glass-covered copper conductors** Part 3—**Round wire: metric units** 4s 6d.

GIVES requirements and dimensions, in metric units, for glass covered round copper wire for electrical machinery and apparatus, the glass covering being a single or double lapping of glass fibre bonded with a suitable highly-polymerized thermosetting varnish. The requirements apply to wires having bare diameters from 0·25 to 4mm inclusive. (See also B.S. 3058 below.)

B.S. 2979: 1958 **Transliteration of Cyrillic and Greek characters** 12s. 6d.

OFFERS two schemes for transliteration: the simple British traditional-type system, which has the full backing of the Royal Society and will be regarded as the standard British method; and the international systems based on Recommendation I.S.O./R9 of the International Organization for Standardization.

B.S. 3026: 1958 **Voltages for high-voltage d.c. transmission systems** 3s.

PROVIDES a range of standard voltages for high-voltage direct-current transmission systems, listing all those known to be in use at present.

B.S. 3040: 1958 **Radio-frequency cables for use with domestic television and v.h.f. receiving aerials** 4s. 6d.

SPECIFIES dimensional and performance requirements, together with methods of test, for r.f. coaxial cables of 75-ohm nominal impedance and diameters over dielectric of 0·128 and 0·200in., and r.f. balanced twin cables of 75-ohm nominal impedance and major dimension of 0·160in.

B.S. 3041: 1958 **Television and v.h.f. broadcast receiving-aerial feeder connectors** 4s.

SPECIFIES two types of connector for receiving-aerial feeders: a coaxial type, for use with television receivers operating in Bands I and III; and a polarized two-pin type for v.h.f. broadcast receivers operating in Band II. The aerial feeder cables suitable for use with these connectors are included in B.S. 3040: 1958.

B.S. 3042: 1958 **Standard test finger** (for checking protection against electric shock) 3s.

GIVES details and dimensions necessary for the construction of the standard test finger and the method of using it for probing cavities and openings in apparatus where there are metal parts which may become live on connection to the mains supply.

B.S. 3052: 1958 **Electric-shaver supply units** 4s. 6d.

APPLIES to fixed supply units for flush or surface mounting containing a transformer with separate input and earth-free output windings and an output socket, or sockets, for the supply of electric dry shavers rated at more than 30 volts and not more than 250 volts a.c. (r.m.s.).

B.S. 3055: 1958 **Rotary switches for domestic electric cookers (a.c. only)** 4s.

DEALS with manually operated rotary air-break switches for domestic electric cookers for use on single-phase a.c. supplies not exceeding 250 volts, giving performance requirements and a suggested method of fixing.

B.S. 3061: 1958 **Electrically heated incubators and cots for babies** 6s.

PREPARED at the request of the Ministry of Health, this is intended to secure a standard of safety from electrical risks and overheating, including fire risk.

B.S. 3058: Part 2: 1958 **Varnish-bonded glass-braided copper conductors** Part 2—**Rectangular conductors** 5s.

GIVES requirements for glass-covered high-conductivity copper conductors of rectangular section for electrical machinery and apparatus, the glass covering being a single braid of glass fibre bonded with a highly-polymerized thermosetting varnish. The specification applies to conductors having thicknesses from 0·035 to 0·24in. and widths up to 0·5in. (See also B.S. 1933 above.)

B.S. 3081: 1959 **Basic dimensions for printed wiring** 3s.

SPECIFIES basic dimensions for printed wiring used in telecommunication and allied electronic equipment. Printed circuits are not included, but the requirements apply to printed wiring forming part of a printed circuit. Striplines for microwave techniques are excluded.

INSTITUTE OF PHYSICS

Design of physics research laboratories Symposium held by the London and Home Counties Branch of The Institute of Physics at the Royal Institution on the 27th November 1957. Chapman and Hall, London, 1959. 21s.

THIS book contains the proceedings of the symposium, i.e. papers and discussion, together with many illustrations, a bibliography and a subject index. Architects and physicists and other users of laboratories are well represented.

NATIONAL BUREAU OF STANDARDS

Circular 598 **Techniques for accurate measurement of antenna gain** by H. V. Cottony (U.S. Department of Commerce, National Bureau of Standards, Washington, D.C., 1958) 1s. 3d. (postage 4d.)*

ALTHOUGH the principles of measuring antenna performance are well known, practical difficulties may cause errors. Comparison of published results of experimental measurements, particularly of antenna gain, reveals apparent discrepancies of the order of one or more decibels. This circular describes techniques developed at the National Bureau of Standards for minimizing the experimental error.

* Available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Remittances should be in U.S. exchange

PAPERS AND MONOGRAPHS
published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings; as soon as these separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within two months of their appearance in the Proceedings.

Applications, quoting the serial number of the paper, monograph or reprint, as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint, as this is the final and correct version and includes the discussion.

PAPERS

Engineering education at the technical universities in Western Germany *Paper* 2913: *Part A*

D. B. WELBOURN, M.A., PROF. D. B. SPALDING, M.A., PH.D., *and* G. L. ASHDOWN

THIS is a paper based on the report of a team of engineers who visited Germany in March 1958 to attempt a comparison of the academic levels achieved in higher engineering education in Great Britain and in Western Germany. Three technical universities, in Berlin, Munich and Aachen, were studied.

The field of investigation was limited to the teaching of mechanical and electrical engineering in these three institutions. The structure of the universities, the appointment of their staffs and the admission of students are described. Full details of courses are given.

To be presented on the 28th May 1959

Problems of engineering education *Report* 2987: *Part A*

PROFESSORS H. G. KAYSER, K. LUERENBAUM, K. MÜLLER, R. SAUER, H. STEFANIAK, *and* R. WILLE

IN this report of a team of German professors who visited England in June and July 1958, the organization of engineering education at university level in England is studied and compared with that in Western Germany.

The engineering faculties of the Universities of London and Cambridge and the colleges of advanced technology at Rugby and Battersea were visited.

The study covers *inter alia* the structure of courses, the appointment of teaching staff, the admission of students, and the relationship between university and professional qualifications.

In addition, the authors note the liaison existing between the colleges of advanced technology and industry (in sandwich courses) and the emphasis which is laid, by both colleges and universities, on the 'social' education of the student (e.g. the provision of halls of residence).

To be presented on the 28th May 1959 at a Joint Meeting with The Institution of Mechanical Engineers

MONOGRAPHS

Electromagnetic energy transfer *Monograph* 333

P. HAMMOND, M.A.

METHODS of calculating and measuring the flow of electromagnetic energy are compared and contrasted. The differences between the low-frequency and high-frequency approaches to energy-flow problems are discussed, and suggestions are made to ease the difficulties of students and teachers faced with these apparently irreconcilable differences.

The gain of travelling-wave ferromagnetic amplifiers *Monograph* 334 E

P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D.

A GENERAL perturbation method for determining the gain of travelling-wave ferromagnetic amplifiers is described. It is applied to an amplifier employing a circular waveguide and an axial ferrite rod of small cross-section.

The efficiency of such an amplifier is shown to be low, and a practical version would demand the use of a larger rod cross-section and/or a slow-wave structure.

Other possible waveguide configurations for amplifiers are briefly mentioned, as well as certain practical aspects of construction.

SOME RECENT BOOKS

W. CAUER

SYNTHESIS OF LINEAR COMMUNICATION NETWORKS—VOLS. 1 AND 2

MCGRAW-HILL. 2ND EDITION (EDITED BY W. KLEIN AND F. M. PELZ). 1958. 866 pp. £7 11s.

THIS is a translation by G. E. Knausenberger and J. N. Warfield of Wilhelm Cauer's classical work 'Theorie der linearen Wechselstromschaltungen'. The translation has been well prepared and reads easily. Furthermore, the book has been brought up to date by the addition of editorial notes and a valuable appendix which, with the aid of a detailed bibliography, summarizes the advances since Cauer's time.

To some readers the notation may seem a little strange, for example the use of λ, instead of p or s, for the complex frequency variable. However, this reviewer was fortunate in having been taught the subject by a lecturer who drew extensively from Cauer, including notation, and many other readers will no doubt be in a similar position.

The book provides a comprehensive treatment, in virtually all aspects, of single- and two-terminal-pair networks. The approach, pioneered by Cauer himself, involves three principal topics, namely realizability, equivalence, and the approximation to a prescribed characteristic by a realizable network function. In the process, all the necessary mathematical tools, e.g. linear algebra, topology, and function theory, are developed, while practical application is assisted by many worked examples and graphical data.

This has always been regarded as the classical work on network synthesis and is likely to remain so for many years. Both the translators and the publishers are to be congratulated on having introduced it to a wider audience.

D. P. CAMPBELL

PROCESS DYNAMICS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 316 pp. £4 4s.

DONALD P. CAMPBELL was known throughout the world of automatic control as the joint author, with Dr. G. S. Brown, of the pioneering book 'Principles of servomechanisms', which in 1948 set a pattern for the future development of the theory of control systems. Until his untimely death in 1957, he devoted his great energy largely to bringing feedback concepts into effective use in the chemical industry. He inspired the teaching of the fundamentals of process control at the Massachusetts Institute of Technology, and much of the impressive achievement in the control of chemical plant in the United States may be attributed to his enthusiasm and participation.

The book on 'Process dynamics' now published was in manuscript at the time of his death and has been competently completed for the press by P. S. Buckley.

It differs in character from others available on process-control problems. It is not an introductory textbook, nor is it concerned with details of apparatus. It presumes acquaintance with the theory of control systems, and it deals with the mathematical forms by which the relationships in a process may be expressed so as to bring them into association with the concepts of the theory.

It makes a great contribution to this large task. It will be an excellent influence towards the much needed unification of the concepts and notation used in process work with those already developed in control. Many of the topics discussed, such as the dynamic behaviour of distillation plants, are complex, but the treatment given clarifies the problems, establishes fruitful methods of analysis and opens a clearer road to further development.

The scope is comprehensive: while it is confined to the mathematical terms expressing 'Process dynamics', a wide range of process relationships are successively brought into servo-equation form. There are chapters on the flow and storage of materials, fluid flow, extrusion and tension control, thermal processes and heat exchangers, mass-transfer and the dynamics of chemical processes. These are all handled similarly, the aim being first to state the basic physical associations, which are of course often non-linear, and then to attempt, at least for some range of operations, to put these relations into the operational form familiar to control engineers.

As a textbook for advanced specialist courses it will be valuable. It includes a collection of interesting and imaginative exercise problems. It will be of use to all engaged in process-control work, not only as a source and reference for important elements of basic theory but also as a stimulus to the attempt to bring still more complex practical situations within the scope of the theory, however intractable they may at first appear.

A. C. CLARKE

VOICE ACROSS THE SEA

MULLER. 1958. 220 pp. 18s.

THE author is to be congratulated on the attractive and absorbing manner in which he describes the history of the commercial ventures resulting in the manufacture and laying of North Atlantic submarine communication cables during the last 100 years.

The early chapters of the volume are devoted to the events leading up to the first successful transatlantic telegraph cable in the 1860's, laid by the famous *Great Eastern*, and the story brings to life all the trials and difficulties which arose before the Continents were spanned.

The author's style is of a happy intimate nature, and the reader has a glimpse into the characteristics and idiosyncrasies of some of the great men of the 19th century, including Lord Kelvin, Heaviside, Wheatstone, Morse, Edison, Clerk Maxwell, and, in particular, Cyrus Field.

The subsequent events leading to the laying of the first successful Atlantic telephone cables in 1956 are described in a manner which makes the volume of great interest to technical and non-technical readers alike. The author concludes with some observations on future possibilities of global communication utilizing satellites, which although fantastic may have the basis of practicality.

W. E. CLASON (*Editor*)

ELSEVIER'S DICTIONARY OF NUCLEAR SCIENCE AND TECHNOLOGY

ELSEVIER. 1958. 914 PP. £7

ELSEVIER'S dictionary is more than a lingual one, since it contains definitions (in English) of the terms used, and it is therefore useful for normal technical consultation. It would be an asset to a college or research organization but perhaps less useful to the individual scientist, who could not extract the maximum value from it without a basic knowledge of all six languages—English, Dutch, French, German, Italian and Spanish.

Judged purely as a technical dictionary it has some faults. Many of the terms (such as *explosive material* and *high-speed electron*) are included simply for the sake of the foreign equivalents and not for their meanings. Most technical dictionaries are considerably broader in scope and contain more terms than the 4000 in Elsevier's. Judged purely from the linguistic viewpoint, it suffers from the defect that Russian is not among the languages represented. It would be thought that Russian papers on nuclear science are not unimportant.

The book is well produced, being clearly printed on good paper and attractively bound. There is a simple cross-reference system between the various languages which facilitates reciprocal translation. The lay-out is spoilt by the addition of an irritating 'subject' column, which tells the reader whether a given term belongs to 'nuclear science' or to 'radiology'. Apart from being pointless, this classification is often wrong (e.g. *chromosome* is labelled 'nuclear science'; *Cerenkov radiation* 'radiology'). As far as can be tested by random dipping, the definitions given are usually clear, succinct and authoritative.

The reviewer's favourite entry is *chinkolobwite*, defined simply as a 'magnesiumuraniumhexahydroxidediorthosilicate'. We live and learn!

H. COTTON and E. W. GOLDING

FOUNDATIONS OF ELECTRICAL ENGINEERING—VOL. 2

PITMAN. 1959. 252 PP. 30S.

'COTTON' has been woven into the fabric of electrical engineering education for over 30 years. There was a time when Cotton's 'Electrical technology' was the only volume of its kind. The author has written on similar lines on occasion in recent years, and now, with a former academic colleague, E. W. Golding, presents the second volume of another basic treatment of electrical technology.

The book is intended for courses at the Ordinary National Certificate level. Its aim is to depart from the 'somewhat uninspiring approach of the orthodox textbook'. The writing is certainly simple, straightforward and clear, making no more demands on the O.N.C. student than he should be able quite readily to concede.

Between Vols. 1 and 2 there has been something of a *volte face*, for the text of Vol. 2 has been couched in M.K.S. terms, and it is evident in the approach ('a changeover in one's mental processes is by no means easy') that the authors as well as their readers are learning the new system.

The scope is substantially what is known as 'alternating currents', with a marked bias towards 50c/s and electrical machines. There are indeed chapters on electronic devices and a.c. measuring instruments, but in general the appeal will be felt more by a reader who copes with electronics only because he has to. Such a reader would agree with the authors that an alternating e.m.f. 'must be obtained by electromagnetic means': thus pretty well wiping the eye of the camera tube, the oscillator, the crystal and the humble microphone as generators of an alternating e.m.f.

There are one or two errors [e.g. Fig. 3.1(*a*) is wrong]; and some irritations, such as 'capaci*ta*tive', the symbol W for power in places, and the torque of a moving-iron instrument given as $5100I^2(dL/d\theta)$ with no clue about where the 5100 comes from except by the implication that the authors have lapsed into C.G.S. units. There are a few curiosities as well: Fig. 1.12 shows a 'Lancashire' turbo-alternator (to be driven from a 'Lancashire' boiler?).

But the book is easy to read, clearly set and well illustrated, and good in its chosen field. The authors are not worried, like some others, about the view that at O.N.C. level it is better to soft-pedal the machines and so give a bit more room to the 'light-current' interests.

L. F. CURTISS

INTRODUCTION TO NEUTRON PHYSICS

VAN NOSTRAND. 1959. 380 PP. £3 13S.

THE advent of nuclear reactors for power production has increased the importance of neutron physics. Many young engineers and physicists will want to obtain a good grounding in the subject. This book provides such an introduction.

The author is a leading research physicist who has specialized in neutron-physics measurements. He begins with the history of the evidence of neutrons' existence, describing their reactions with other nuclear particles. He then moves on to his main subject: neutron bombardment and how to detect, measure, produce and control it. There are many short sections dealing with the background theory to all the processes and techniques discussed, and the result is a clear and readable work.

Of particular interest to many potential readers is the chapter dealing with neutron sources. This is a very complete account and should be valuable to all concerned with setting up neutron sources for experimental and other work. To ensure accurate and safe applications of neutron physics, the author includes a review of calibration and standards as well as a detailed section on shielding and protection of personnel. Altogether, this is a volume which can be recommended to the serious student.

P. E. K. DONALDSON

ELECTRONIC APPARATUS FOR BIOLOGICAL RESEARCH

BUTTERWORTH. 1958. 718 PP. £6

HERE is a monumental collection of circuit knowledge, laboratory techniques and workshop procedures appropriate to a physiological laboratory. It is addressed to research workers and others in the biological field who are concerned in the design, construction, and maintenance of electronic equipment.

It is in four sections. Part one concerns circuit theory, from Ohm's law to attenuators, bridges and filter networks. Part two is practical and discusses components and their practical ratings. Part three deals with transducers and indicators. Part four is largely examples of complete equipments synthesized from the implication in the earlier sections and has good sections on fault location and the suppression

of interference. There is a final chapter on transistors and a review of their possible uses.

The scientific subject-matter is well and accurately presented, making the work a most valuable source of information for physiologists and their technicians. It is not, however, a book from which electrical engineering can be learnt, since few of the formulae are derived from fundamental considerations (unless indeed the Fourier transform of formula 1 is the basis for all!).

The practical chapters are most serviceable. How useful it can be to know the ampere-hour capacities of various types of dry cell and the likely leakage rates of various designs of capacitor. The sections on biological electrodes and intracellular probes are good and up to date. A chapter on workshop equipment underestimates the advantages that accrue to a hospital or research laboratory from a well equipped tool-room. If transducers and recorders are going to be made or adapted to special needs, a drilling machine, lathe and milling machine are surely necessities rather than luxuries.

The book should find a place in all biological research laboratories and will be more than helpful to engineers concerned with the design of electro-medical apparatus.

G. W. A. DUMMER

MODERN ELECTRONIC COMPONENTS

PITMAN. 1959. 472 PP. £2 15S.

WRITTEN by a recognized authority on the subject, this book is essentially factual and is intended mainly to guide and help those engineers whose concern is the design, development, manufacture and maintenance of electronic equipment.

Apart from comprehensive descriptions of the physical and electrical characteristics of the whole range of electronic components, including resistors, capacitors, inductors, cables, switches, plugs, sockets, etc., there are valuable chapters on the means employed to meet the need for apparatus to operate in conditions of considerable shock and vibration, tropical heat and humidity, or Arctic cold.

The importance of the reliability of components in the fields of atomic-energy control and guided weapons is emphasized; but, strangely, no mention is made of electronic digital computers, electronic exchanges or submarine-cable repeaters, all of which impose extreme demands on equipment reliability.

The volume is packed with useful information, and, with one exception, the balance between the various chapters is well maintained. The exception is the chapter dealing with inductors and magnetic materials, which is rather skimped, particularly of drawings or photographs, and which makes no reference to pressed insulated metal-powder cores.

These are minor criticisms, however, of an excellent work.

J. W. DUNGEY

COSMIC ELECTRODYNAMICS

CAMBRIDGE. 1958. 183 PP. 32S. 6D.

MAXWELL'S equations sum up the laws of electromagnetism in a form particularly suitable for field problems. When Alfvèn applied these equations to cosmic problems it became clear, first that there were considerable differences in emphasis between the laboratory and cosmic scales, and secondly that it was necessary to combine with the electromagnetic laws those of fluid dynamics.

A very large part of Dr. Dungey's book—five out of the nine chapters—is devoted to basic theory, much of which is also applicable to the highly ionized plasmas of thermonuclear experiments. Essentially it is a review of the present state of these somewhat new theories rather than a textbook, and it is a review of a mathematical subject by a mathematician who has himself made notable contributions thereto. It assumes a familiarity with the concepts of Boltzmann gas kinetics, of Chapman–Enskog non-uniform gas theory and of fluid mechanics, as well as with the vector theorems of electromagnetic fields.

For those so versed, it is indeed a valuable review, for the author takes great care in pointing out how and where the changes in emphasis from the classical 'laboratory' picture must be heeded. Chapter 1, 'Preliminaries', is occupied particularly with this aspect and includes a section on causal relationships. The following chapters discuss the statistical as against the particle description, the motion of magnetic fields, magnetostatics, magnetodynamics, and high-energy particles. The final chapters deal with applications to solar phenomena, magnetic storms and the ionosphere.

Only a few problems in these fields have yielded to detailed treatment, while a formidable array await further advances. There are in fact so many difficulties that one is tempted to wonder whether even yet the physical picture is adequate.

P. EISLER

TECHNOLOGY OF PRINTED CIRCUITS

HEYWOOD. 1959. 405 PP. £3

THIS is a somewhat lengthy review of printed-wiring techniques, dealing in detail with the etched-foil method. It is a composite volume in that much use is made of other authors' work, although full acknowledgment is always given. The field is adequately covered, and seven appendices are used to cover further specialized detail. There is nevertheless a lack of balance in the work; for instance, dip-soldering techniques are dismissed in two pages, while nine pages are devoted to 'Regeneration of ferric chloride', which might well have been put in an appendix.

Some of the chapters will be most useful to the designer and user of printed wiring. There is a particularly good chapter on the repair of printed wiring and another on microwave printed circuits (by R. M. Barrett), while the practical details of laboratory routine (by G. Parker) will be valuable to the electronics engineer setting up a new printed-wiring laboratory.

Too much emphasis is placed on the importance of printed wiring, particularly in the opening chapters, and on miniaturization and microminiaturization, which have been made possible by semiconductor development not by printed wiring.

On the whole, the book should be useful to the electronics engineer designing or using printed wiring. The bibliography (compiled by Mrs. K. Bourton) is extensive and includes 481 references.

W. L. EVERITT (*Editor*)

FUNDAMENTALS OF RADIO AND ELECTRONICS

CONSTABLE. 2ND EDITION. 1959. 805 PP. £2 17S. 6D.

REMEMBERING the considerable advances in radio and electronics which have taken place since 1942, one can understand the editor's desire to bring his 'Fundamentals of radio' up to date. It is, however, difficult to assess its value to the reader as the authors give no indication of the status of student or engineer for whom it is intended. Judging by the contents, it

has been written for a student whose mathematical ability is of the order of Ordinary-level G.C.E.

Starting from a consideration of vulgar fractions, the authors aim to lead the student by paths involving a minimum of mathematical analysis to an appreciation of radio, radar technology and the industrial applications of electronic devices. Such a wide range of subject-matter in a work of approximately 800 pages suggests a superficial treatment; this assumption is borne out by detailed study of specific topics.

As an example of this criticism, the addition of two phasors at an arbitrary phase angle is merely stated as a peculiar property of a sinusoidal signal, with no attempt at a more rigorous justification. Again, in an attempt to give a physical insight into electrical quantities, rigour of definition is frequently missing; this is illustrated in the retention of the old electrochemical definition of the ampere.

The book is profusely and, on the whole, satisfactorily illustrated; the omission of the considerable number of photographs showing the external appearance of electronic apparatus would certainly not reduce its utility.

It appears to be designed to give superficial knowledge to a student who wishes to know 'how' electronic apparatus works but is not sufficiently interested to inquire 'why'. It could only be recommended to a serious student as supplementary to some more rigorous treatment.

W. FRASER

TELECOMMUNICATIONS

MACDONALD. 1957. 772 PP. £3 5S.

THE author, a lecturer in the Department of Electrical Engineering at King's College, London, has set out with the laudable objective of writing a comprehensive textbook on telecommunication. A vast amount of ground is covered in the 22 chapters which go to make a very substantial volume—unfortunately some 50% more substantial than a typical American textbook having the same number of pages.

The first third of the book deals with passive networks and lines and covers the ground pretty well, though it is a pity to find Bartlett's bisection theorem tucked away in 'Attenuators and filters' instead of 'Network theorems' and not given in its complete form. It is regrettable too that non-preferred nomenclature is so often used in connection with lines and networks.

The author next deals reasonably adequately with conventional valves and transistors and proceeds to cover amplifiers (including negative feedback), oscillators, modulators, etc., very competently in the second third. The remainder is devoted to basic considerations of information and its transmission, microphones and reproducers, telephony (one chapter), telegraphy, high-frequency lines and waveguides, v.h.f. valves and radio propagation. Each chapter includes worked examples, questions culled from London University and Institution Examination papers (with answers at the back of the book) and a list of references; these are all invaluable and represent the best practice in this type of work. Nowhere does the author balk at mathematics when this can usefully serve his purpose.

There is a foreword by Sir Archibald Gill, and the appendices include Mathematical formulae, M.K.S. units, Fourier analysis and Maxwell's equations. Despite its shortcomings —including a number of printer's errors—this is a most valuable offering for a wide range of university and technical-college students, up to degree standard. It is also a useful reference for telecommunication engineers working in not-too-specialized fields; nowhere, however, does it take the reader to the forefront of specialist developments.

J. W. FREEBODY

TELEGRAPHY

PITMAN. 1959. 738 PP. £4

THE important place occupied by telegraphy in our telecommunication services is often not fully appreciated, and as a result study of the subject tends to be neglected. This book should help to correct that situation, because it not only puts telegraphy in its proper perspective but also shows how many problems of real scientific interest there are in this field.

As a successor to the well known volume by T. E. Herbert, this book represents the latest standard work on the subject dealing with both principles and practice. It opens by briefly tracing the development of telegraphy from its early days and then proceeds to discuss, successively, manual, automatic, time-division multiplex, start-stop, facsimile and picture transmission systems. There is a section concerned with telegraph-line theory and network analysis, together with some special consideration of the problems of submarine-cable working.

Physical principles and their applications are presented with a thoroughness and attention to detail that is wholly admirable, but the theoretical part is less satisfactory. Proofs of some of the mathematical relations are given in an appendix, but a number of results are just quoted without support. Surprisingly enough, this applies to Kelvin's classical work on the 'curve of arrival'.

Nevertheless, taking the book as a whole, there can be no doubt about its value as an important contribution to the literature.

E. H. FROST-SMITH

THE THEORY AND DESIGN OF MAGNETIC AMPLIFIERS

CHAPMAN AND HALL. 1958. 487 PP. £3 15S.

THIS authoritative and comprehensive volume is the first of a new series on automation and control engineering, and it becomes immediately apparent that it has been written by an expert of standing in the field, who knows the difficulties of a really logical treatment of non-linear circuit analysis and has largely surmounted them.

Introductory chapters on ferromagnetism and the basic operation of the transductor are followed by a series of chapters on the detailed analysis of transductors, their steady-state and transient operation, self-excitation, auto-excitation, and behaviour with reactive loads.

At this stage the closed-loop control system is introduced, and the transient- and spectral-response functions of transductors are derived. The following chapters discuss special topics such as high-speed magnetic amplifiers, balanced circuits, low-level and cascade amplifiers, and magnetic modulators. An important chapter deals with construction and design procedure, and finally some applications are described.

The mathematical treatment is thorough but fairly elementary, and graphical presentation is used extensively for the non-linear analysis. Transfer functions based on operational methods are employed for the description of transient phenomena but not elaborated in detail. The algebraic

development is followed in all relevant places by numerical examples, and the ample illustrations in the text help greatly towards an understanding of the analysis. There are some plates which mainly show the general construction of equipment and are therefore not always revealing.

The synthetic treatment of the chapter on construction and design is, however, particularly useful. Altogether, the work can be thoroughly recommended and may well establish itself as the standard textbook in this field.

K. HENNEY and C. WALSH (*Editors*)

ELECTRONIC COMPONENTS HANDBOOK—VOL. 2

McGRAW-HILL. 1958. 357 PP. £4 17S.

THIS publication contains chapters on power sources and convertors; fuses and circuit-breakers; electrical measuring instruments; printed-wiring boards; solders and fluxes; choppers; blowers, drive motors and filters; and r.f. transmission lines and waveguides.

All are discussed with reference to their application in electronic apparatus of all sizes. Particularly in relation to rectifiers, uses with heavy currents and many kilowatts of power are mentioned. The components are treated with the requirements of the relevant United States specifications in mind. This implies some limitation to the utility of the work in the United Kingdom—some references to the British specifications would have added to its value.

Each chapter includes much general descriptive matter, with many curves and tables on the properties of the components. In spite of the fact that the type and reference numbers are of U.S. origin and not applicable elsewhere, the general matter is of sufficient importance to form a useful working textbook which could be valuable to all students. Some of it is rather elementary, but much sound advice is given.

A small criticism may be levelled at the occasional use of unexplained abbreviations. This is a not uncommon habit of American authors.

The printing is good and the diagrams clear and well reproduced.

P. HENRIET

FONCTIONNEMENT ET PROTECTION DES RÉSEAUX DE TRANSPORT D'ÉLECTRICITÉ

PARIS: GAUTHIER-VILLARS. 1958. 372 PP. £2 5S.

IN view of the world-wide interest in developing hydro-electric power and other natural resources remote from load centres, in nuclear power generation, and in long-distance transmission and the interconnection of large networks, this French volume, which discusses many of the problems involved, is opportune. France, with its mixed power system and its connection to the European Grid network, is naturally interested in these problems.

P. Ailleret, in his preface, emphasizes both their importance and the competence of the late P. Henriet to deal with them. His recommendation of the author is, however, barely necessary; even a casual inspection of the work shows that it is authoritative and written by a master of his subject.

It is based on lectures at the École Supérieure d'Électricité and embraces the experience and results of many transmission studies by Électricité de France. Yet its content is quite generally applicable. The author has succeeded admirably in maintaining close liaison between the underlying theories of network analysis and practical problems.

In so wide a field it was obviously necessary to limit the scope, and only alternating-current transmission and distribution are dealt with in detail. But the treatment is comprehensive; many practical cases are studied, and conclusions are set out at appropriate intervals. The style is excellent, simple and direct with no waste of words, while the numerous diagrams complement the text well. The explanations of network models and the descriptions of protective systems are commendable. Assuming, as it does, a thorough knowledge of electrotechnics, this is a book for the transmission engineer or advanced student and must be regarded as a valuable contribution to the literature.

R. A. HIGONNET and R. A. GREA

LOGICAL DESIGN OF ELECTRICAL CIRCUITS

McGRAW-HILL. 1958. 220 PP. £3 17S. 6D.

THIS is a treatise on the application of mathematical logic to switching circuits. Switching circuits are most commonly found in telephone exchanges but also occur in a variety of computing and controlling devices. When very complex systems are to be designed, the use of the logical methods described in this book may be of great value, although some engineers find they are able to design intuitively.

It opens with a chapter on Boolean algebra and elementary set theory. This is made easy to understand by the use of Euler circle diagrams. Those readers familiar with computing circuits will, at first, miss a direct reference to the logical operations 'and', 'or' and 'not'. The algebra is applied to relay circuits in some detail.

An alternative approach is then developed, using geometrical representations, in which the various possible circuits of two relays are represented by a square, those of three relays by a cube, and those of four relays by a four-dimensional hypercube. Other chapters are devoted to methods of simplifying circuits and to systems in which circuits are switched sequentially.

The work will be of interest to engineers who specialize in the design of large switching systems.

R. B. HURLEY

JUNCTION TRANSISTOR ELECTRONICS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 473 PP. £5

ALTHOUGH this cannot be classified as a textbook, reference book or designers' handbook, it should appeal to many engineers. It sets out to teach, and only in so far as it omits adequate descriptions of, reasons for, and analyses of the electrical properties when leading up to equivalent circuits does it fail the reader. But it is a good introduction to the ways of applying transistors, meeting most of the aims of the author and being written in a good style.

The space saved by the condensation of the physical background is not wasted in the later chapters, which deal with a wide variety of usages—in power amplifiers, d.c. amplifiers (electronic choppers might, however, have been given a little detailed attention), d.c. regulators, video and bandpass amplifiers, sinusoidal oscillators (the account of which terminates rather abruptly), modulators, non-regenerative and regenerative switching circuits, and saturable reactor circuits. The biasing of transistors, unilateralization, and methods of controlling the gain of amplifiers are not overlooked.

An even standard and pace are maintained almost throughout, which is evidence, perhaps, of the author's teaching

experience. The analytical work is adequate, and little seems out of place—except a few new symbols. Even the introduction of Laplace transforms in the chapter on switching need not dismay the less mathematically-minded readers.

Here and there the book momentarily forgets transistors, e.g. when explaining, at some length, the effects of negative feedback and when introducing switching mathematics; but it does so without warranting serious criticism. A few diagrams are unnecessarily large, but otherwise the presentation is excellent.

J. KOCH (*Editor*), R. H. V. M. DAWTON, M. L. SMITH and W. WALCHER

ELECTROMAGNETIC ISOTOPE SEPARATORS AND APPLICATIONS OF ELECTROMAGNETICALLY ENRICHED ISOTOPES

NORTH-HOLLAND. 1958. 314 PP. £3 2S.

THIS book is undoubtedly a labour of love, since the potential readership must be fairly limited. It is to the authors' credit that they have undertaken the task of providing a small but extremely valuable group of research workers with an authoritative textbook.

The subject-matter is essentially practical, concerning itself almost exclusively with the design, construction and operation of electromagnetic separators. It is a useful supplement to the many theoretical volumes already in existence.

The work falls naturally into three sections. The first part deals with small and medium-sized separators suitable for installation in physics laboratories, and it also contains a historical account of mass spectrography (the pre-war name for the electromagnetic separation of isotopes). The second part describes large separators used for the production of gramme and milligramme quantities of isotopes and includes a wealth of detail of the Oak Ridge and Harwell machines. A good third of this section is devoted to the authors' operational experience and to the applications of enriched isotopes. The last part discusses the design problems encountered in the construction of modern separators. This final section will be of interest to those electrical engineers who are called on to supervise the manufacture of large separators.

The lay-out of the volume is logical and attractive; there are many good-quality line and half-tone illustrations and abundant references to the literature; the indexing is adequate.

D. A. LEVELL

PULSE AND TIME-BASED GENERATORS

PITMAN. 1958. 175 PP. 25S.

THIS short work is intended as an introduction to pulse and time-base waveform generators for such applications as radar, television, and electronic instrumentation.

After a short historical background, it has chapters on the elementary analysis of linear and non-linear circuits. The following chapters deal with pulse modulators and with trigger circuits of the soft-valve, blocking-oscillator, multivibrator and negative-transconductance type, and in conclusion there are short chapters on electromagnetic time-bases and on transistor circuits.

The outstanding merits of the volume are the continuity and easy flow of the text and the clarity of the presentation. The linear treatment is covered by elementary but adequate mathematical analysis, the non-linear parts being mainly descriptive and graphical, with ample illustrations. It follows from the limited scope of the book that detailed accounts cannot be given of many circuits, but each chapter has a short bibliography to facilitate further reading.

The main criticism is perhaps one of balance: transistor circuits are dismissed very briefly and without any quantitative data—in contrast to the broader account of some classical circuits now falling into disuse.

It is an excellent work for the student and a useful introduction for the engineer entering this field for the first time.

H. S. W. MASSEY and H. KESTELMAN

ANCILLARY MATHEMATICS

PITMAN. 1958. 990 PP. £3 15S.

THE title chosen for this book is that of courses in mathematics in the University of London, for which the topics were selected by the Physics and Chemistry Boards of the University; but it is to be hoped that the title will not prevent its use by many outside the ranks of the students for whom it was designed.

It is written with the all-too-rare policy of assuming only a moderate prior knowledge (G.C.E. Advanced-level mathematics) but examining all its topics both reasonably rigorously, so as to lay a foundation for further studies, and lucidly. It aims at covering those topics in mathematics which are of special importance to non-mathematicians.

It is a large book, but the authors explain that students of different subjects will select different parts of it; and what a wealth of material from which to select! Dipping in, one finds absolute convergence, brachistochrone, canonical distribution, difference equations, eigen-values (in relation both to sets of linear equations and to differential equations), factors of polynomials, Newton's laws of motion, quadratic invariants, Taylor's theorem, umbilic, and Wheatstone's bridge.

One must not, however, suppose that it contains *all* the mathematics needed by the physicist or engineer—it is only offered as a first-year course. The electrical engineer will require also a course on functions of the complex variable and on transforms; and both engineer and physicist may need to learn three-dimensional vector notation and at least the notation of matrices, if only to be able to read the current literature of their subject. Moreover, the authors make no attempt to cover statistics, which in these days is surely just as deserving of the title of 'applied mathematics' as the traditional Newtonian dynamics.

Those who have passed the days of examinations may none the less like to keep this book at hand as a refresher or as an introduction to some mathematical topic which they are having to take up for the first time.

F. E. NIXON

PRINCIPLES OF AUTOMATIC CONTROLS

MACMILLAN. 1958. 409 PP. 30S.

THIS is an engineer's introduction to servomechanism theory and design. The main part concerns frequency-response methods and the use of the Nyquist plot and *M*- and *N*-circle diagrams. Bode diagrams and root loci are dealt with briefly. Laplace-transform methods are used for transient-response calculations, and connections between transient and frequency responses are described, but the inverse-transform relations are not included.

Many examples and problems are given, mostly without reference to particular engineering devices. Cascade and minor-loop compensation are discussed at some length, with

a useful commentary on the practicability of various alternative methods. The author rightly lays stress on numerical methods of solution, to the extent of devoting an appendix to a second-order Runge–Kutta procedure.

A few matters which are dismissed perhaps too briefly are: non-minimum-phase functions (although process control, where these abound, is not within the scope of the book); alternative criteria to minimum integral-of-error-squared; and the whole of non-linear theory. It also seems odd to introduce numerical analysis without mentioning finite-difference methods, at least as a check on mistakes. A common practice is followed of classing a delay as a non-linear element.

These are, however, small points in a well written, sound, and reasonably priced book, and, if books on control ever ran to a second edition, they would doubtless be modified. The format is good and the index adequate; the bibliography shows signs of having been written before 1954.

H. F. OLSON

DYNAMICAL ANALOGIES

VAN NOSTRAND. 1958. 278 PP. £2 11S.

THE author is concerned to demonstrate the analogies that exist between vibrating mechanical and acoustical systems and electrical circuits. Once these analogies are established, it becomes possible to express a particular class of problems in mechanics and acoustics in terms of equivalent electrical circuits and so to apply the whole of the well developed electrical-circuit theory in the solution of those problems.

The book includes chapters on the equivalent mechanical, acoustical and electrical circuit-elements; simple systems with one and two degrees of freedom; corrective networks; wave filters; transducers; noise and distortion; feedback; the mobility analogy; and the magnetic-circuit analogy (though this is hardly a dynamical analogy). These last three chapters are new or expanded compared with the first edition. There is also an expanded chapter of examples. The author is well known for his work in acoustical engineering, and his book is an exposition of some ideas that acoustical engineers have found so useful.

It is difficult to guess (and the author does not say) for whom the work is written. It can hardly be the electrical engineer, who would find the treatment of fundamentals sketchy. For example, Kirchhoff apparently enunciated only one law. And in considering the chapter on the mobility analogy (that in which mechanical impedance is defined as the ratio of velocity to force) the electrical engineer would invoke the magic word 'duality' and save himself a lot of work. Here is an idea from well developed circuit theory which has *not* been applied.

Proponents of the M.K.S. system of units will regret to find that the C.G.S. system is used throughout, so that abvolts, abamps and abohms abound. Here, if anywhere, is a field in which the M.K.S. system comes into its own.

If, on the other hand, the book is intended for mechanical and acoustical engineers there is the difficulty that 'the text assumes on the part of the reader a familiarity with the elements of alternating circuit [*sic*] theory. . . .' If this assumption is justified, the omission of any treatment of the idea of the circuit, which after all is the key idea which enabled circuit theory to develop, is understandable. However, if the reader is prepared to go elsewhere to learn his circuit theory, this is a useful collection of examples of the application of the theory.

C. A. OTTO (*Editor*)

ELECTRIC FURNACES

NEWNES. 1958. 248 PP. 35S.

THIS volume will be welcomed by engineers and metallurgists, particularly as there are few British works on the subject.

The importance of the subject of electro-heat is receiving increasing recognition. There is, for example, the trend towards replacing open-hearth furnaces by large electric arc furnaces in 'cold metal' steel-making practice; and recently a British National Committee on Electro-Heat has been formed.

The book is not, of course, written primarily for the electrical engineer; though the publishers' claim, that it will be of help to engineers, to engineering students and to all those interested in the use of electro-heat for industrial purposes, is a reasonable one.

It is mainly descriptive and largely deals with particular equipments. With 11 specialist contributors, there is inevitably a certain amount of repetition; but a wide if somewhat superficial coverage of the field of electric furnaces is provided, as may be gathered from the chapter headings: Electrical phenomena, Types of electric furnace, Metal-melting furnaces, Indirect resistance furnaces, Heat-treatment of metals and alloys, Induction heating, Vacuum furnaces, Salt-bath furnaces, Electric heat in the glass industry, Vitreous-enamelling furnaces, Electric heat in the pottery industry, Electric heat in the plastics industry, Control and measurement equipment, and Refractories and furnace linings.

Two rather serious criticisms may be made. First, no references whatever are given to sources of information; and, secondly, the index is poor: for example, there is no index reference to 'melting', though the subject is well covered in the text. There is no index reference to the important subject of protective atmospheres, and this is only briefly mentioned in the text.

These criticisms aside, it will be found a useful book by anyone interested in electric furnaces.

J. R. RAGAZZINI and G. F. FRANKLIN

SAMPLED-DATA CONTROL SYSTEMS

McGRAW-HILL. 1958. 331 PP. £3 14S.

THIS is an outstanding achievement. 'Sampled-data control systems' is an intricate and difficult topic, which has occasioned some very turgid writing. Ragazzini and Franklin have now provided a systematic account of it which is not only intelligible but is a pleasure to read. It is logical in development and has the crystal clarity that springs from a profound grasp of the fundamentals combined with great skill in writing. It is a model of good exposition.

An outstanding merit of the book is the way in which the interrelation of the various approaches to the analysis of pulsed systems is clarified. The authors move with equal facility in the fields of frequency response, finite differences and recursion formulae, Z-transforms and numerical approaches such as time-series methods; and these appear with their equivalences and interrelations instead of as unrelated alternatives.

The treatment does not presume prior knowledge of the subject, and is an excellent introduction. It does presume some knowledge of the complex variable and of complex integration. It covers all the fundamental aspects and successfully avoids the long algebraic dissertations on secondary matters that might easily have impaired it. After introductory chapters on 'sampling' and 'clamping', the Z-transform

technique is explained, with excellent examples of its application. The relation to digital-computing devices is clearly brought out. There is a chapter on 'multi-rate sampling systems', i.e. those in which at least two sampling devices operate at different rates, and an excellent chapter on sampled-data systems with random inputs.

The volume will be of the greatest use both to students and to practising engineers and can be recommended to all who wish to find their way into this fascinating subject not only without tears but with a sense of pleasure and exhilaration.

R. N. RENTON

TELECOMMUNICATIONS PRINCIPLES (IN M.K.S. UNITS)

PITMAN. 2ND EDITION. 1958. 446 PP. £2 5S.

THIS book provides an introduction to the principles of telecommunication engineering and is designed to cover the examination syllabus for Telecommunications (Principles) I, II and III of the City and Guilds of London Institute.

It differs from the earlier edition in the use of rationalized M.K.S. units, and the reader is able to follow the text without reference to any other system. Numerous worked examples help to induce familiarity with the M.K.S. idea, and an appendix provides the interrelation between this and other systems. In the chapter on magnetism, a number of topics such as inverse-square-law calculations and a magnetometer description have been omitted, a modification which helps to focus attention on the more useful aspects of the subject.

In general, the form is the same as in the earlier edition. The treatment is generally clear and is illustrated by plenty of helpful diagrams. The subjects covered extend from fundamentals of electricity to transmission theory and thermionic valves, together with a helpful chapter on sound. The mathematics in the text is kept to a minimum, and some mathematical notes are incorporated in an appendix. As a result, the book will be of great help to those who are studying in this field and will also be useful to those who wish to refresh their ideas on fundamental principles.

J. THOMSON and E. B. CALLICK

ELECTRON PHYSICS AND TECHNOLOGY

ENGLISH UNIVERSITIES PRESS. 1959. 527 PP. £2 10S.

THE science of electronics as it is today embodies a close study of the properties of matter, particularly in the solid and gaseous phases. The very important semiconductor developments, which include crystal valves of all kinds, and solid-state masers taking advantage of the different paramagnetic energy levels and using a high-frequency pump to stimulate emission of radiation, are but two examples of the kind of application coming within the scope of this subject.

The book begins very properly by introducing the reader to some of the fundamental concepts of matter, giving special attention to metals, gases and semiconductors. These concepts, which rely to some extent on quantum mechanics, are not easily interpreted; and while the authors have no doubt done their best in the short space available, many readers will probably find it necessary to supplement the information given by a study of other texts.

In the succeeding pages there is an excellent discussion of both thermionic and crystal valves, the authors having drawn with great success on their wide experience in this field. Not only are the basic principles clearly set out but the technology of the subject finds an important place, enabling a good comprehensive picture of the various aspects to be presented. In addition, there is a very helpful treatment of some of the more specialized electronic devices, such as those used for signal storage, switching, cameras and photo-electric applications.

As happens not infrequently in books of this kind, the same symbol is used for a number of different purposes. In the present volume the choice of s to represent, on the one hand, the spin quantum number and, on the other, one of the electron states is particularly unfortunate, since its two meanings occur side by side in the same context.

Such deficiencies are, however, of a comparatively minor character, especially when one considers the over-all value of the work in bringing together so effectively such a wide range of material.

The authors and the publisher are to be congratulated on their success in a difficult achievement.

J. G. TRUXAL (*Editor*)

CONTROL ENGINEERS' HANDBOOK

McGRAW-HILL. 1958. 1105 PP. £7 3S. 6D.

THE difficulty with this large volume is that it has the word handbook in its title, and consequently one expects it to be a handbook. In fact, it is very much more. One feels that the places where it runs true to type are incidental to its main purpose, which is to convey the quintessence of experience of practical control engineering in all its various aspects.

Now this is a very difficult task to undertake, and it is not surprising that the authors are not invariably successful. Nevertheless, the book represents a quite remarkable achievement in a fashion which is new and likely to be emulated by others. The reader who has experience will recognize many things which he had to learn the hard way. It is always pleasing to feel that authors know their stuff, and in reading this work one has that impression frequently. The band of people who contributed to this phenomenon were clearly carefully chosen and were, it seems, firmly progressed by the editor, for they must be people busy in the practical matter of control engineering.

Coverage is very broad, with chapters on control theory and design, including applications of computers, and detailed sections on components; amplifiers (magnetic, valve, transistor, thyratron, relay and electro-mechanical); mechanical components; hydraulic and pneumatic components; and transducers. There is even a brief discussion of process control. It is all there, somewhere; and this is one of the prime assets of the book. Practically all the useful dodges, experience, hints and tips have been condensed into one comprehensive volume, which as a result is not very portable.

Some sections may be selected for particular mention. There is a good chapter on non-linear analysis, a fairly good account of circuit synthesis, an exhaustive examination of d.c. amplifiers for operational use, a useful discussion of d.c. and a.c. motors and tachometers, and a very valuable description of mechanical components and gears.

There is such a wealth of factual detail that one cannot read the book steadily; but it is easy to dip in here and there and almost invariably come up with some titbit of information, suspected or previously unknown, arising in the experience of one of the authors. The book will be very valuable, as it was clearly intended to be, for those who must produce results in as short a time as possible and be sure they have not missed existing techniques or recent technical advances.

Elections and transfers

The following elections and transfers approved by the Council are effective from the 1st April 1959

ELECTIONS

Member

HINTON, Sir Christopher, K.B.E., M.A., F.R.S.

Associate Members

AITKENHEAD, John, B.SC.
AMOS, Lt. John Headon, M.A., R.N.
ARONSON, George, B.SC.TECH.
BOLAM, Flt.-Lt. George Dennis, M.A., B.SC., R.A.F.
BRADYLL-JOHNSON, Cmdr. Victor Alexander Leslie, R.N.(RET.)
CASTELL, John
EASTON, Ernest Iveson, B.E.
HUININK, Gerard Everhard Ten Bokkel
JERVIS, William Brian
MAURER, Cecil John, B.SC.(ENG.)
MUGGERIDGE, Reginald
PRICE, Robert
RAO, Bangalore Vasudeva Rao Suryanarayana
RIMMER, Edward
ROSE, Gordon Albert, B.E.
SARSTEDT, Hubert Mervyn, D.L.C.
THORNE, Reginald Lewis, B.COM.
WEEKS, Robert John, B.SC.(ENG.)
WHITTLE, Harry Reed, B.E.
YEH, Warner Shao-Yin, B.SC. M.A.

Associates

PARKER, Lt.-Cmdr. George, R.N.
WILLIAMS, John Clifford
YOUNGER, Kenneth

TRANSFERS

Associate Member to Member

AKERHIELM, Claes Edward, D.F.H.
AXON, Peter Eric, O.B.E., PH.D., M.SC.
BENINGTON, Leslie William
BUCKLEY, Rear-Admiral Kenneth Robertson, R.N.
CAMPNETT, Leslie William
CLAXTON, Edgar, B.SC.(ENG.)
CLODE, Capt. Roger Leslie, R.N.
JACKS, Eric
OVERTON, Bryan Richard, B.SC.(ENG.)
PERKINS, George Karl
POLLARD, John Robert, M.A.
SPANSWICK, John Roland, B.SC.(ENG.)
VAN ESCH, Theodorus Joannes, B.SC.(ENG.)
VASNAIK, Michael Albert Joseph, B.SC.(ENG.)
WALLER, John Reginald
WEBB, Ronald Alexander
WILLIAMS, Francis Edward, M.SC.(ENG.)
WILLOUGHBY, Anthony Haydn, B.SC.(ENG.), B.SC.
WYKE, Richard Edgar Budden

Graduate to Associate Member

ALDERSON, Michael Stanley, B.SC.(ENG.)
ANSTEY, Leslie Maryatt, B.SC.(ENG.)
ASHTON, Ernest Hugh, B.SC.(ENG.)
BALHARRIE, David McNicoll
BARNES, Raymond, B.SC.
BAUSOR, John
BELL, Derrick Clifford
BETTS, Peter Ernest, B.SC.(ENG.)
BOWN, Norman William Orton
BOXALL, Reginald Charles, B.SC.(ENG.)
BOYES, Ronald Henry
BULLOCK, Hedley
BUNDAY, Derek Cecil
BURROWS, George Arthur
BUTTERY, Peter Joseph
CALEB, Gordon
CAMPBELL, Colin Gibson, B.SC.
CASTELL, Roy
CHAPPELL, Kenneth Henry
CHECKETTS, Guy Tresham, B.SC.(ENG.)
CLOUGH, Leonard Derrick
CLUCAS, John Harold
COLLINS, Frank James
CORY, Brian John, B.SC.(ENG.)
DANIEL, Frederick Leonard Upton, B.SC.(ENG.)
DAWE, Thomas Russell
DOOLEY, Harry, M.SC.(ENG.)
DOUGLAS, Andrew Marshall, A.R.C.S.T.
DRYDEN, Leonard
EVANS, William Roger
FARRAND, Ronald, B.SC.
FLANDERS, Richard David
FRIEDGUT, David, B.SC.(ENG.)
GEARY, Robert Arthur, B.SC.(ENG.)
GEDDES, Eric William
GOLDFINCH, Raymond Arthur, B.SC.(ENG.)
GOLDTHORP, John Roland
GREENWOOD, George Leslie
GRICE, Kenneth Stanier
HADDOW, Leslie Martin, B.SC.(ENG.)
HANNA, Ian Gordon, B.SC.
HEATH, Frederick George, B.SC.
HEMINSLEY, William Frank
HICKS, George Michael, B.SC.(ENG.)
HILL, Dennis Walter, M.SC.
HOWE, Frank Ralph
HUGHES, Frank Farmer, B.SC.(ENG.)
JEFFS, Stanley Christopher, B.SC.(ENG.)
JOUGHIN, Donald Cannell, B.SC.(ENG.)
KENDON, Martin Honess, B.SC.(ENG.)
KEOGH, Patrick Leslie
KING, Michael Harold Ross, B.SC.(ENG.)
LAURENCE, Walter Hayes, B.SC.
LONDON, Alan George, B.SC.(ENG.)
MCCALLUM, Ian Bruce
MIRANDA, Isidore Michael, B.A.
MORGAN, John Harold, B.A.
MOSTYN, Eric Richard
NASSIM, Eliahou Ishaq Hakham, B.SC.(ENG.)
PALMER, Victor Alfred
PHILP, William Kenneth
PLATT, John Edward
POMFRET, Alan
PORTER, Albert
REID, William Wood
ROBERTSON, Kenneth Gordon, B.SC.(ENG.)
ROCHE, Mark Mordechai, B.SC.
ROSEN, Phillips Reginald, B.SC.(ENG.)
ROWLEY, Eric Hubert
SLADE, Ronald Charles
SOMASUNDARAM, Ariaratnam James, B.SC.(ENG.)
TAYLOR, Alan Heatley, B.ENG.
TAYLOR, Edward David
THOMSON, John Johnston, A.H.-W.C.
WALLACE, Nigel Glyn, B.A.
WARD, Geoffrey Marcus, B.SC.
WARD-COX, Richard Bertram Antonie Matare
WARSHAW, Nigel Claude, D.F.H.
WOLLEY, John Toole, B.SC.(ENG.)
WORTH, Geoffrey
WYATT, Arthur John, B.SC.(ENG.)
YOUNG, Michael Victor, B.SC.TECH.
ZEIHER, Graham

Student to Associate Member

GREEN, Kenneth James, B.SC.(ENG.)
SELBY, Gordon Rainton, B.SC.(ENG.)
SHELTON, William Timothy, B.SC.

The following elections and transfers approved by the Council are effective from the 2nd April 1959

ELECTIONS

Graduates

AGARWALA, Siddhi Sadhan Swarup, M.SC., PH.D.
AIREY, Eric
ALLEN, George Martin, B.SC.(ENG.)
ANDERSON, George Mair
BALAKRISHNAN, Triplicane Vijaragava, B.E., M.SC.
BARR, George Salmond
BATES, Thomas
BEAL, John Campbell, B.SC.(ENG.)
BEAUMONT, Graham Reginald
BEVAN, Malcolm Aneurin
BUCKINGHAM, Brian Edward, B.SC.(ENG.)
BURKMAR, James Thomas, B.SC.(ENG.)
CASTRUCCI, Plinio Benedicto de Lauro
CHANG, Frank Tse-Yah, D.F.H.
CHAPLEO, Charles John
CHURCHILL, Russell Joseph, B.E.
CLAMP, David Warwick Lloyd, D.L.C.
COOPER, Colin, B.A.
DRAKE, Albert Stanley
EVANS, Maj. Raymond Vincent, B.SC., R.E.M.E.
FARRELL, Alan Richard
HEARD, Brian David, B.SC.(ENG.)
HOLLYWOOD, Roger John
HOPKINS, Bradley Victor
HUGHES, Daniel, B.ENG.
JACKSON, John Barry, B.A.
JOHN, Joseph Devadasan Azariah
KEECH, Anthony Francis
KENNEDY, Conor Thomas, B.E.
MCCARTHY, Francis Desmond, B.E.
MURPHY, Patrick Aubrey Dennis
NUTTALL, Alan Wadman
O'BOYLE, Sean, B.E.
OWENS, Anthony James, B.ENG.
PAVLAKIS, George Augustus, B.SC.
PEPERMANS, Andre, B.SC.(ENG.)
REECE, Terence James
REES, Kenneth Stanford
REEVES, Sidney William George, B.SC., B.SC.(ENG.
SANJEEVIRAO, Mallipudi Srirama, B.E.
SHAW, Andrew
SIDHAN, Thevalil Chathunny, B.E.
SILVER, Phillip Laurence, B.E.
SMITH, Eric
SOUCH, Geoffrey
SPENCER, Gerald Lansdowne, B.SC.
STELMACH, Antoni Leslaw
TAYLOR, Denis Frederick
THOMAS, Gordon James
TODD, David Laurie
TOMLINSON, John Michael Gawthorpe, B.SC.
TUDBALL, Raymond Samuel
WALKER, Robert David, B.A.
WEBBER, Robin Thomas Basil
WHINCUP, David John, B.SC.
WHITMORE, Malcolm George, B.SC.
WILLIAMS, Howard Sidney, B.SC.
WITTING, Jerzy Czeslaw, B.SC.(ENG.)

Students

ABIGAIL, James Trevor
ADAMS, Ernest, B.SC.
ALLAN, Ronald Norman
ANDREWS, Eric Roy
BAKER, Albert George
BAKER, Richard Ingram
BARKER, Anthony David
BEACHAM, Rodney William
BELLAMY, Howard John
BELLANY, John, A.H.-W.C.
BEST, Robert Herron, B.SC.
BOURNE, Allan
BOWD, David Morris
BUCKLEY, Trevor
BUTLIN, Roger John
COWLING, James Richard Carver
CHAN, Bill Ling
CHANDLER, Henry John, B.A.
CHAPPELL, Terence Roy
CHARLETT, Paul Francis
CHRISP, Michael Hillary
CLARK, John Charles
CROWE, John Alexander
CURTIS, Michael Willard
CUTTRISS, Henry Noel
DAW, Michael James
DAWE, Robin Barry
DENNE, Phillip Raymond Michael, B.SC.
DIMENT, Vyvyan Edmund
DINSMORE, Robert Eagleton
DUCKWORTH, Fred, B.SC.TECH.
ESTLIN, Boyd Warren
FARRER, John Bruce
FIGGINS, Timothy James George, B.SC.
FISHER, Forest Francis Rutley, B.A.
FOLEY, Brian John
FROST, David John
GARFIELD, Brian Ronald Charles
GEORGE, Royston Arthur
GILL, Anthony Roger
GOODMAN, James Edwin
GOSDEN, William Lionel
GOTH, Diana Raby
GRINYER, David Leslie
GRIZZELL, Richard Laurence, B.SC.(ENG.)
GROVES, Philip Rangecroft
HALL, Kenneth Leslie
HARVEY, Robert
HAWKER, Robert John
HAY, James
HERBERT, Edward Colin
HILDER, Richard Ian
HILL, Michael John
HITT, Roger
HUMPHREY, Derek
HUNTER, Garry
IRVING, Philip Byron
JACKSON, David
JAMES, John Richard
JENKINS, David Arthur Leonard
JOLLY, John Thomas
JONES, Kevin Michael
KERVELL, Michael George
KIRKE, William Rupert Anthony

Students (continued)

LEE, Brian
LOVERIDGE, John Edwin George
LUXTON, Peter Kenneth John
MAAS, Michael Jan, B.A.
McCANN, David Michael
McCREA, Samuel Brendan
McLAREN, James
McNALLY, Kevin Harvey
MAIN, David Thomas
MALLINSON, James Eric
MANUEL, Joseph Antony Yuvaraj, B.SC.(ENG.)
MANVELL, Michael
MAPLES, Graham Christopher
MASON, Douglas Fawcett
MEHTA, Harshad Ishvarlal
MEIKLE, John Hay
MELTON, Laurence Richard Arthur, B.SC.
MILLER, Phillip John
MILNE, John Gilbert, B.SC.
MITCHELL, William George
MOSS, Peter Barrie
MUSTAFA, Dilaver
NAIK, Atul Mahadev, B.SC.
NATTRESS, Barry
NAYLOR, William
NEWLAND, Anthony Thomas John
NORRIS, Thomas
OGRAM, Douglas Walter
PETROU, Michael
PLENTY, Adrian Colin
PONTING, Philip James
POOLEY, Anthony Richard
QUIGLEY, Michael Bernard Coupland
RANDALL, Charles Passmore
REES, Julian, B.SC.
REICHER, George John, B.SC.
RICHENS, Kenneth Lionel
RIGG, Barry
ROBERTS, Janet Mary
ROBERTSON, Derek Maitland, B.SC.(ENG.)
SHIMWELL, Alan John
SLACK, Alan
SMITH, Brian
SMITH, Brian Duncan
SMITH, David Kingsley, B.SC.
SMITH, John Barrington Miles
SPARY, Raymond Arthur
STACEY, Peter James
STATT, Alan John
SUMMERS, Colin Henry
SUTTON, Bryan
SWEIG, Raymond Gerald
TERRY, Peter David
THOMAS, Delme Sewell
THOMAS, Geoffrey
TILLEN, Peter John
TRUCKELL, Antony George
TURNER, William George
VANDERSTEEN, Anthony David
WALTERS, Peter Francis
WARD, David Edward
WEIL-MALHERBE, Claude Michael
WELLBELOVED, Robert
WHEATON, John Edward George
WHITEHOUSE, David John, B.SC.
WHITEHOUSE, Joseph Colin, B.SC.
WHITMELL, Brenda Constance
WILLCOCKS, Brian Edwin
WILLIAMS, Howard Bradbury
WILLIAMS, John
WILLIAMSON, David George
WOOLF, Brian David
WRIGHT, John Milford
YEO, Sebastian
YOUNGER, Christopher Landon
YUE, Kan Kong

TRANSFERS

Student to Graduate

ALLIN, George, B.SC.(ENG.)
ANDREWS, Stanley Henry, B.SC.
BATY, Joseph Smith, B.SC.
BONNY, John McCartney, B.SC.
CAMPBELL, William John, B.SC.(ENG.)
CARSON, William, B.SC.
CHRISTY, Roger John, B.SC.(ENG.)
COCKS, Frank Dennis, B.ENG.
CULLEN, Edgar Goldsmith Elliott, B.SC.
DAVIS, Bernhard, B.SC.TECH.
FUNG, Norman, B.ENG.
GADRE, Arvind Trimbak, B.ENG.
GAME, Peter Robert, DIP.TECH.(ENG.)
GEE, Lawrence Frederick, B.SC.
GLEN, Alistair William Martin, B.SC.
GORDON, Alfred Henry, A.H.-W.C.
GRIFFITHS, Ronald, B.SC.
HOPPER, Ronald James, B.SC.(ENG.)
HULME, Henry Gordon
JOWETT, Barrie Furman, B.SC.
JULIEN, Kenneth Stephen, B.SC.
KIRKHAM, Roy
LOWE, George Hsien Tsou, DIPL.ING.
MILLER, Vincent Eugene, M.SC.
MORGAN, Stanley, B.SC.
ROBERTS, David John, B.SC.TECH.
RUSSELL, David Michael, B.SC.(ENG.)
SCOTT, James Millar, A.H.-W.C.
SINGH, Karam, B.SC.
STUBBS, Barry
TANDON, Brij Kishore, B.SC.
WILLIAMS, Ivor Keith, B.SC.(ENG.)
WILLSON, Richard George, D.L.C.
WITHER, Alan Peter, B.SC.

• Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members

LIBRARY ACCESSIONS

BOOKS

CARR, L. H. A., and WOOD, J. C.. 347.77

Patents for engineers*

London, Chapman and Hall, 1959. pp. 107. 22 × 14cm. 18s.

This volume is intended for engineers, and the authors have sought to avoid as far as possible legal phraseology and irksome detail and to present the basic outlines of the law in simple form. The picture is completed by a chapter on registered designs, copyright and trade marks; and historians will be interested in the description of outstanding historic electrical patents. To be reviewed.

EVERITT, W. L. (*Editor*) 621.396

Fundamentals of radio and electronics. 2nd edition*

London, Constable, 1958. pp. xiv, 805. 23·5 × 15·5cm. £2 17s. 6d.

The scope includes radio, television, radar, radio navigation, h.f. induction heating and diathermy for intermediate-level students. Transistor applications and colour television are included in this edition. Reviewed on p. 322.

FRANK, E. 621.317

Electrical measurement analysis*

London and New York, McGraw-Hill, 1959. pp. xiii, 443. 24 × 16cm. £3 8s.

With a minimum of descriptive matter, this book concentrates on the principles and inherent errors of instruments and methods of measurement, reducing them to broad categories. The analysis and statistical treatment of errors are fully demonstrated. To be reviewed.

GARDNER, M. 518.5

Logic machines and diagrams*

London and New York, McGraw-Hill, 1958. pp. ix, 157. 24 × 15·5cm. 39s.

A survey of mechanical and electrical machines designed to solve problems in formal logic and of geometrical methods for doing the same thing.

KIRCHMAYER, L. K. 621.311.003

Economic operation of power systems*

New York and London, Chapman and Hall, 1958. pp. viii, 260. 24 × 15cm. £4 16s.

A full explanation of how data on incremental generation costs and transmission losses in power supplies can be submitted to computers. Instances of the operating economies thereby gained are cited from the experience of American supply undertakings, together with worked examples and references to further reading. To be reviewed.

LEFSCHETZ, S. (*Editor*) 534

Contributions to the theory of nonlinear oscillations—Vol. 4

Princeton, Princeton University Press, 1958. pp. v, 211. 25·5 × 17·5cm. 30s.

A further volume in a series of advanced discussions of non-linear differential equations. The papers are relevant to specialized problems in electromagnetic systems and automatic control.

McCRENSKY, E. 37

Scientific manpower in Europe. A comparative study of scientific manpower in the public service of Great Britain and selected European countries

London, Pergamon Press, 1958. pp. ix, 188. 22 × 14·5cm. £2

Based on interviews with prominent persons, this book, by an American author, gives a general background to the practice in the public service of several countries and to methods adopted for improving recruitment, retention, training and utilization. Personnel management, salary scales and other pertinent matters are discussed.

MALGORN, G. 413 = 40

Lexique technique français–anglais (French–English technical dictionary)

Paris, Gauthier-Villars, 1956. pp. xxviii, 475. 20·5 × 14cm. £2 10s.

This technical dictionary includes electrical and radio terms.

MINISTRY OF POWER 662.6

The efficient use of fuel. A textbook on fuels and their efficient utilization for the use of students and technical men in industry. **2nd edition**

London, H.M.S.O., 1958. pp. vii, 888. 25 × 15cm. 35s.

In this edition, the chapter sequence has been rearranged and the text adjusted to take note of changes in techniques and materials since 1944. Literature references have been added.

RATCLIFFE, J. A. 551.594

The magneto-ionic theory and its applications to the ionosphere

Cambridge, University Press, 1959. pp. x, 206. 22 × 14·5cm. £2

Deals with the theory of electromagnetic waves passing through the ionosphere. Part 1 includes the derivation of Appleton's complicated equations, which express the refractive indices and the wave polarizations for waves travelling in a magneto-ionic medium. Part 2 summarizes the results in graphical form, while part 3 discusses the application of the theory to the ionosphere. To be reviewed.

SHEPHERD, J., MORTON, A. H., and SPENCE, L. F. 621.3

Higher electrical engineering. A textbook for students in Higher National Certificate courses*

London, Pitman, 1958. pp. x, 566. 22·5 × 14·5cm. £2

Intended to cover A1 and A2 years of the Higher National Certificate course and to be adequate for either light- or heavy-current work in the second year. The rationalized M.K.S. system is used throughout, and there are numerous worked examples and problems to be solved by the reader. To be reviewed.

TATON, R. 50

Reason and chance in scientific discovery*

London, Hutchinson, 1957. pp. 171. 24 × 15cm. 30s.

Examines the relative roles of active purpose and chance in the processes of scientific discovery and gives an insight into the workings of the inventive mind. Examples in various branches of science are based on the lives and works of many eminent men, including Ampère, Poincaré, de Broglie, Faraday, Galileo, Newton and Volta. Detailed name and subject indexes add to the value of this work.

THOMSON, J., and CALLICK, E. B. 621.38

Electron physics and technology*

London, English Universities Press, 1959. pp. viii, 527. 22 × 14·5cm. £2 10s.

Introductory chapters give an account of the basic principles of modern electron physics. A description follows of the functioning and construction of various devices, considering space-charge and microwave equipment, special-purpose tubes, materials and construction methods. Reviewed on p. 327.

WOOTTON, W. R. 621.039

Steam cycles for nuclear power plant*

London, Temple Press, 1958. pp. vii, 66. 22 × 14cm. 10s. 6d.

An elementary explanation of the many considerations involved in selecting steam cycles for nuclear power plant of the gas-cooled graphite-moderated and water-cooled water-moderated types.

THE following 13 volumes, under the general heading 'Atoms for peace', were United States contributions to the second International conference on the Peaceful uses of atomic energy, Geneva, 1958

BISHOP, A. S. 539.17

Project Sherwood. The U.S. program in controlled fusion

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £2 5s. 6d.

CHASTAIN, J. W., JUN. (*Editor*) 621.039

U.S. research reactor operation and use

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £3

CLAUS, W. D. (*Editor*) 539.16

Radiation, biology and medicine. Selected reviews in the life sciences

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £4 12s.

CLEGG, J. W., and FOLEY, D. D. (*Editors*) 669.8

Uranium ore processing

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £3

CUTHBERT, F. L. 669.29

Thorium production technology

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £2 12s.

DIETRICH, J. R., and ZINN, W. H. (*Editors*) 621.039

Solid fuel reactors

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £4 8s. 6d.

HOLDEN, A. N. 669.8

Physical metallurgy of uranium

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £2 5s. 6d.

KRAMER, A. W. 621.039

Boiling water reactors

Massachusetts, Addison-Wesley, 1958. 24 × 15·5cm. £3 8s.

LANE, J. A., MACPHERSON, H. G., and MASLAN, F. (*Editors*) 621.039

Fluid fuel reactors

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £4 12s.

NAVAL REACTORS BRANCH 621.039

Shippingport pressurized water reactor

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £3 16s.

SEABORG, G. T. 669.8

The trans-uranium elements

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £2 16s.

STARR, C., and DICKINSON, R. W. 621.039

Sodium graphite reactors

Massachusetts, Addison-Wesley, 1958. 23·5 × 15·5cm. £2 12s.

WEINBERG, A. M., and WIGNER, E. P. 539

The physical theory of neutron chain reactors

Chicago, University of Chicago Press, 1958. 23·5 × 15·5cm. £5 12s.

OTHER PUBLICATION

INSTITUTE OF THE AERONAUTICAL SCIENCES

1958 National Telemetering Conference. Papers presented at Baltimore, Maryland, June 2–4, 1958

New York, Institute of Aeronautical Sciences, 1958. pp. 317. 28 × 21·5cm. 32s.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 20TH APRIL 1959

	No. of Contributors	£	*s.*	*d.*
£1000 and over	7	8000	0	0
£100 to <£1000	30	6586	3	0
£5 to <£100	879	9259	14	5
£2 to <£5	2174	5968	2	0
under £2	26204	13651	2	1
		£43465	1	6

ADDITIONAL MEETING

MEMBERS are asked to note that the following Joint Meeting with The Institution of Mechanical Engineers is additional to the programme published in the meetings card:

Thursday, 28th May 1959 D. B. Welbourn, M.A., Prof. D. B. Spalding, M.A., PH.D., and G. L. Ashdown 'Engineering education at the technical universities in Western Germany' (Paper 2913) and Professors H. G. Kayser, K. Luerenbaum, K. Müller, R. Sauer, H. Stefaniak, and R. Wille 'Problems of engineering education' (Report 2987). (In the Library at Savoy Place at 5.30 p.m., tea at 5 p.m.)

APPOINTMENTS AND NOMINATIONS

WIRING REGULATIONS COMMITTEE

On the nomination of the Engineering Equipment Users' Association, the Council have appointed Mr. T. A. Frazer, M.A., ASSOCIATE MEMBER, to serve on the above Committee in place of Mr. G. E. Skillington, MEMBER.

OVERSEA REPRESENTATIVES

The Council have appointed Mr. F. S. Barton, C.B.E., M.A., B.SC., MEMBER, and Mr. F. L. Lawton, B.A.SC., MEMBER, as their Oversea Representatives for Ontario and Quebec, respectively. Dr. J. M. Thomson, M.A.SC., MEMBER, the present Oversea Representative for Canada, will continue to cover other parts of Canada.

COUNCIL FOR CODES OF PRACTICE

The Council have nominated Col. B. H. Leeson, C.B.E., T.D., PAST-PRESIDENT, to serve on the above Council in succession to Mr. J. R. Beard, C.B.E., M.SC., PAST-PRESIDENT.

CODES OF PRACTICE COMMITTEE FOR ELECTRICAL ENGINEERING (ELCP/–)

The Council have nominated Mr. H. M. Lacey, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee in succession to Mr. J. F. Shipley, MEMBER.

B.S.I. SUB-COMMITTEE ELE/3/2—SHIPS' CABLES

The Council have nominated Mr. E. E. Hutchings, B.SC.(ENG.), MEMBER, to serve as their representative on the above Sub-Committee in place of Mr. A. Henderson, MEMBER.

B.S.I. SUB-COMMITTEE ELE/32/6—RADIO INTERFERENCE SUPPRESSION IN MARINE INSTALLATIONS

The Council have nominated Mr. A. G. Stonebanks, ASSOCIATE, to serve as their representative on the above Sub-Committee in place of Maj. B. Binyon, O.B.E., MEMBER.

CITY OF BIRMINGHAM EDUCATION DEPARTMENT—ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING FOR TECHNICAL COLLEGES IN BIRMINGHAM OTHER THAN THE BIRMINGHAM COLLEGE OF TECHNOLOGY

The Council have nominated Mr. L. L. Tolley, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee.

CANNOCK CHASE MINING AND TECHNICAL COLLEGE—ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. J. C. Christie, B.SC., ASSOCIATE MEMBER, to serve as their representative on the above Committee.

STOCKPORT COLLEGE FOR FURTHER EDUCATION—ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. H. G. Brown, ASSOCIATE MEMBER, to serve as their representative on the above Committee.

NATIONAL COMMITTEE ON SPACE RESEARCH

The Council have nominated Dr. J. S. McPetrie, D.SC., MEMBER, to serve as their representative on the above new Committee.

SUBSCRIPTIONS AND NATIONAL SERVICE

UNDER a recommendation approved by the Council, the subscription payable by Graduate and Student members during their term of National Service is reduced to 10s. per annum. A member wishing to take advantage of this dispensation should advise the Secretary, giving the date of his call-up.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

MEMBERS are reminded that notifications of change of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one Local Centre or Sub-Centre to that of another arises as a result of a change of address, the transfer is automatically arranged by head-

quarters, and the member concerned need not notify also the Honorary Secretary of the Local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested, when notifying a change of address, to give their full initials, their previous address and their class of membership.

CORRESPONDENCE

IN view of the heavy volume of correspondence received daily at the offices of The Institution, it is of the greatest assistance when members, in replying to letters received from the Secretary, quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches the department concerned without delay but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

BENEVOLENT FUND

THE Court of Governors are pleased to acknowledge a contribution of £1 to the Benevolent Fund, sent by an anonymous donor.

MEMBERSHIP OF LOW-TEMPERATURE GROUP

THE Physical Society has as one of its specialist bodies a Low-Temperature Group. Realizing the increasing likelihood of association between members of their group and electrical engineering, they recently arranged to extend a privilege rate of subscription to applicants who are members of The Institution.

Further details may be obtained from the Low-Temperature Group of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London S.W.7.

RESIDENTIAL CONFERENCES AT BIRMINGHAM

TWO informal residential conferences in September 1959 are being organized by the Electrical Engineering Department of the University of Birmingham. To preserve informality, numbers attending the conferences are being strictly limited.

The first, on dielectric devices, will be held from Monday, 14th September to Thursday, 17th September 1959; and the second, on modern network theory, will take place from Monday, 21st September to Thursday, 24th September 1959.

Full details are available from the Secretary of the Electrical Engineering Department, The University, Birmingham 15.

INTERNATIONAL CONGRESS ON MICROWAVE VALVES

THE Verband Deutscher Elektrotechniker are planning to hold an International Congress on Microwave Valves at Munich from the 7th to 11th June 1960.

Further information will be issued shortly, and members interested in receiving this are invited to communicate with the Reception and Information Office, 'Mikrowellenröhren', Brienner Strasse 40, München 37.

INTERKAMA 1960

THE second INTERKAMA (International congress and exhibition for Instrumentation and automation) will take place at Düsseldorf from the 19th to 26th October 1960. The first meeting of the congress advisory board was held recently at Düsseldorf.

INTERNATIONAL CONFERENCE ON IONIZATION PHENOMENA IN GASES

THE Fourth International Conference on Ionization Phenomena in Gases, to be held in the University building, Uppsala, Sweden, from the 17th to 21st August 1959, has been arranged by the University of Uppsala in collaboration with the Swedish National Committee for Physics.

The main subjects to be discussed include: fundamental processes in gas discharges; high-frequency, glow, arc and spark discharges; high-temperature plasmas and controlled fusion; instabilities and oscillation in gas discharges; and new methods of measurement. Abstracts of contributions should not exceed 350 words and must be received by the 15th June.

Inquiries concerning the conference and requests for application forms should be sent to the Secretary-General, Dr. Åke Nilsson, Institute of Physics, Uppsala, Sweden.

CONFERENCE ON INSTRUMENTATION

THE Annual Conference of the Instrument Society of America will be held in Chicago from the 20th to 25th September 1959. Its theme will be 'World progress in instrumentation', and particular stress is to be laid on the use of computers for process control and on photo instrumentation.

Further details may be obtained from the Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pennsylvania, U.S.A.

COMMUNICATIONS SYMPOSIUM

COMMUNICATION systems and equipment and related techniques will be covered in the Fifth National Communications Symposium, sponsored by the Professional Group on Communications Systems of the Institute of Radio Engineers, to be held at the Hotel Utica, Utica, New York, from the 5th to 7th October 1959.

Contributions are invited covering all phases of communication. Papers describing new or proposed system standards and approaches to provide integrated communication systems are especially sought. Prospective authors are asked to submit an abstract of 100–150 words not later than the 30th June 1959.

Further details may be obtained from the Institute of Radio Engineers, 1 East 79 Street, New York 21, N.Y., U.S.A.

15TH NATIONAL ELECTRONICS CONFERENCE

CHICAGO, 12TH–14TH OCTOBER 1959

AT the 15th Annual National Electronics Conference, to be held in the Hotel Sherman, Chicago, U.S.A., from the

12th to 14th October 1959, it is planned to discuss these topics, among others, during the technical sessions: servo-mechanisms, communication systems, computers, micro-waves, plasma research, solid-state circuits, space electronics, and television.

The conference is sponsored by the American Institute of Electrical Engineers, the Institute of Radio Engineers and a number of other organizations; more particulars are available from the National Electronics Conference, 228 North La Salle Street, Chicago 1, Illinois, U.S.A.

ELECTRICAL TECHNIQUES IN MEDICINE AND BIOLOGY

NOVEMBER CONFERENCE

ON the 10th–12th November 1959, the 12th Annual conference on Electrical techniques in medicine and biology will be held in the Sheraton Hotel, Philadelphia, Pennsylvania.

Sponsored by the Joint Executive Committee in Medicine and Biology, appointed by and representing the pertinent interests of the American Institute of Electrical Engineers, the Institute of Radio Engineers for its group on Medical Electronics, and the Instrument Society of America, the conference has as its object the further advancement of the scientific area between the medical and biological sciences on the one hand and electrical engineering principles on the other.

A part of the conference will be concerned with various forms of non-ionizing radiation, and individual sessions will deal with microwaves, infra-red and ultraviolet radiation, and ultrasonic techniques.

Proposals for contributed papers are invited and should be submitted to Dr. L. E. Flory, RCA Laboratories, Princeton, N.J., U.S.A., before the 1st July 1959.

CENTRIFUGAL STRESSES IN TURBO-ALTERNATOR ROTORS

A PAPER on the subject of 'Centrifugal stresses in turbo-alternator rotors', by Mr. H. Fessler, has been published by The Institution of Mechanical Engineers.

A limited number of copies of this paper are available free to members with an interest in the subject who apply to the Secretary of The Institution of Electrical Engineers.

Contents of the current issues of the *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (APRIL 1959)

See the Journal for April 1959, p. 248

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (MAY 1959)

C. L. S. GILFORD, M.SC. PAPER 2676 R, JUNE 1958 **The acoustic design of talks studios and listening rooms** *March 1959*

W. C. BAIN, M.A., B.SC., PH.D., AND E. D. R. SHEARMAN, B.SC.(ENG.). PAPER 2963 E **Observations on the U.S.S.R. earth satellites and the study of radio-wave propagation** *May 1959*

R. G. HIBBERD, B.SC. PAPER 2914 **Transistors and associated semi-conductor devices** (*Review of progress*) *May 1959*

H. T. PRIOR, B.SC., D. J. R. CHAPMAN, B.SC., AND A. A. M. WHITEHEAD, B.SC. PAPER 2722 R, SEPTEMBER 1958 **The application of transistors to line communication equipment** *March 1959*

H. G. BASSETT, B.SC.(ENG.), D. THOMSON AND P. E. GREENAWAY, B.SC. PAPER 2764 R, DECEMBER 1958 **The application of junction transistors to audio-frequency telephone line amplifiers** *April 1959*

M. P. ATKINSON, B.ENG., W. T. BANE, B.SC., AND D. L. A. BARBER, B.SC. PAPER 2859 M **A design for an automatic graph plotter** *May 1959*

A. M. THOMPSON, B.SC. PAPER 2887 M **The cylindrical cross-capacitor as a calculable standard** *April 1959*

M. R. CHILD AND D. J. SARGENT, B.SC. PAPER 2832 E **A method for the accurate measurement of mutual conductance of thermionic valves** *May 1959*

J. A. SAXTON, D.SC., PH.D., AND B. N. HARDEN, M.SC. PAPER 2807 E **The performance of directive aerials in complex u.h.f. fields** *May 1959*

E. G. A. GOODALL, M.SC. PAPER 2849 E **Hemi-isotropic radiators for the S- or X-band** *May 1959*

G. CRAVEN AND V. H. KNIGHT. PAPER 2852 E **The design and testing of integrally constructed waveguide assemblies** *May 1959*

P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D. PAPER 2796 E **A perturbation method for circular waveguides containing ferrites** *May 1959*

PART C. MONOGRAPHS (MARCH 1959)

See the Journal for March 1959, p. 192

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E ELECTRONICS AND COMMUNICATIONS SECTION
O ORDINARY
S SUPPLY SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published separately. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card.

May 1959

S **20** *Wednesday* P. J. SQUIRE, B.SC.(ENG.). Annual Lecture: 'The World Bank—what it is, what it does, and how it works'‡

E **21–27** *Thursday–Wednesday* International convention on Transistors and associated semiconductor devices (all wishing to attend are required to register; registration forms are available on application to the Secretary) (to be held at Earls Court, London S.W.5) The programme is on p. 294

S **23** *Saturday* Section visit to Aldermaston

O **28** *Thursday* D. B. WELBOURN, M.A., PROF. D. B. SPALDING, M.A., PH.D., *and* G. L. ASHDOWN 'Engineering education at the technical universities in Western Germany' (Paper 2913) *synopsis:* see p. 319; PROFESSORS H. G. KAYSER, K. LUERENBAUM, K. MÜLLER, R. SAUER, H. STEFANIAK *and* R. WILLE 'Problems of engineering education' (Report 2987) *synopsis:* see p. 319 (Joint Meeting with The Institution of Mechanical Engineers)

June 1959

15–19 *Monday–Friday* Summer Meeting in the North Midland Centre

‡ No advance information will be available

BULLETIN OF THE SECTIONS

UTILIZATION

What's in a name?

ALTHOUGH a keen member of the Section, I must confess to some antipathy to its name. This may be because of the ugly, angular appearance of the 'z' in the title or perhaps a mental association with the term 'utility', which so often refers to articles necessary but without grace or beauty. At least one other specialized Section has recently changed its name, and it would be good to see suggestions for other titles which might be more elegant if not more apt.

The importance of the scope of the Section, however, cannot be questioned, as it covers all matters relating to the utilization of electrical energy other than such specialized applications as telecommunication service and radio. It is on the success in this field that the future development of generation and supply depends.

Committee deliberations

Regularly the Section Committee review the wide field of the Section with a view to stimulating the preparation of papers. Agriculture, domestic applications such as space heating, traction, and electricity in ships are some of the topics under consideration which are of interest to every member of The Institution because of the impact these matters have on their lives.

Local Centre committees too often have difficulty in selecting papers for their programme which have a wide enough engineering interest to appeal to a mixed rather than a specialized audience. From the subjects mentioned above, it should be possible to encourage papers of such general interest.

Considerâtion of the programme of the Section during this present session reflects this wide general interest. Papers have been read on the electrification of the United Kingdom Atomic Energy Authority's industrial group factories, on the electrical installation at an atomic-energy station, on traction and on fusegear. It is noteworthy that Local Centres and Sub-Centres have used a number of Utilization Section papers in their programmes during this session.

Papers of specialized interest are, of course, equally welcome, and during the year a number of papers have been accepted on research investigations of particular value to the designer of electrical plant.

The young engineer

Among recent events, one of particular interest was the Joint Meeting with the London Graduate and Student Section held on the 12th March 1959, which is reported below. It is encouraging for the future that the young authors at this meeting should have presented their papers so well and dealt with the discussion so competently. Those who attended considered that the meeting had been instructive and well worth while. J. M. F.

Fuse discrimination

THE capabilities and limitations of an old friend of the installation engineer were under review at Savoy Place on the 12th February 1959, when Mr. E. Jacks presented a paper entitled 'Discrimination between h.r.c. fuses', which dealt with the factors on which discrimination depends and related them to current practice. Mr. R. A. Marryat was in the chair. A short review of this paper appears on p. 304.

The author pointed out that these factors require a knowledge of the way fuses function and an appreciation of the conditions in which they work in service. He also stressed that a satisfactory fuse throughout its service life must remain faithful to its published characteristics, as, by its very nature, it cannot be rechecked for accuracy of these nor can it be recalibrated. The performance of a modern h.r.c. fuse, however, can be accurately predicted. A rule of thumb was put forward to the effect that the current rating of each fuse should be half that of its predecessor, and a simple analytical basis was suggested for checking whether discrimination can be relied on between two fuses in short-circuit conditions.

The discussion, which was essentially of a practical character, was opened by Mr. G. E. Skillington, who expressed his satisfaction that manufacturers were making a determined effort to provide adequate information to enable cartridge fuses to be employed by users to the best advantage; he also said that the correct descriptive words were 'high breaking capacity' and not 'high rupturing capacity'. Regarding this latter point, one speaker observed that the appropriate British Standard was not particularly enthusiastic about 'h.b.c.', although it took a somewhat dim view of 'h.r.c.'.

Among other views expressed were the great need to educate users that h.r.c. fuses should provide back-up protection rather than overload protection, and that overloading and surges when motors were started direct on line were conditions which could lead to fuse deterioration. It was also urged that more work should be done on the protection of d.c. circuits by h.r.c. fuses. R. H. R.

Coal, paper and switchgear

IN accordance with now established practice, one meeting of each session is devoted to the reading and discussion of a number of short papers presented by younger members. On the 12th March 1959 at Savoy Place, this event took the form of a Joint Meeting with the London Graduate and Student Section.

The first paper, entitled 'Coal-mining and electricity', was read by Mr. A. P. Foster and was followed by an interesting discussion.

A paper was then given by Mr. P. D. House, dealing with 'Electric drives in the paper industry'. In the discussion which ensued, there was evidence of somewhat grudging tributes

to the effectiveness of electrical salesmanship, in that one contributor observed that he 'tried to make paper despite the electrical equipment which has been provided by manufacturers', while someone else referred to the 'complications which the electrical engineer loves to add without making any more paper'. A review of Mr. House's paper appeared in the March 1959 *Journal*, p. 165.

The final paper, on 'Standardization and simplification of switchgear', was presented by Mr. M. J. L. Willison. One speaker, who, like his father, has been closely associated with this particular field of electrical engineering, announced proudly that such standardization was practised in his family as far back as 1909. Mr. Willison's paper is reviewed on p. 309 of this issue.

The quality of all three papers and the able manner in which the replies to the discussions were handled fully maintained the high level which is such a feature each year of these particular meetings, and this was reflected in the very warm support which was given to the vote of thanks to all three authors, which was proposed by Mr. F. P. Harwood, the Honorary Secretary of the London Graduate and Student Section.

R. H. R.

SUPPLY

Air-break switchgear

Any paper on switchgear is bound to attract a full audience and a lively discussion, and the paper by Messrs. F. S. Fay, J. A. Thomas, D. Legg and J. S. Morton at the meeting at Savoy Place on the 25th February 1959 was no exception. Mr. D. P. Sayers was in the chair. The paper (reviewed on p. 311) deals with the development of high-voltage air-break circuit-breakers with insulated-steel arc-chutes. To avoid any confusion it should be noted that the circuit-breakers described in this paper are air-*break* (as opposed to air-*blast*), operating in free air without compressors or other ancillary machinery of that sort.

Most papers on development tend to describe the final result without including the many and laborious steps and the difficult decisions which have to be made, but this paper indicates some of the work which had been abandoned before the final device was perfected.

Mr. C. H. Flurscheim opened with a discussion of the comparative merits of air-blast and oil circuit-breakers. He holds that air at atmospheric pressure is a poor insulator and that this type of breaker cannot be as good as an oil circuit-breaker. This type of breaker cannot explode; on the other hand, explosions of oil circuit-breakers are very rare. Fires are, in fact, more likely with an air circuit-breaker than with an oil circuit-breaker; and the only comparative advantage of the former is ease of contact maintenance.

Both Mr. J. A. F. Harvey and Mr. A. H. Pollard are developing air circuit-breakers, and they revelled in the details of the paper, telling the authors where they were right and where they were wrong and how they could improve their device.

Mr. C. W. Mott stated that a number of theories expressed in the paper were not new but that the authors deserved credit for being the first to investigate such theories practically. He regretted that the authors had not said more about a complete air-break panel.

Mr. J. Solomon stressed the need for development of circuit-breakers for generating-station auxiliaries to match up with the increasing size of generators. He commended the authors' use of M.K.S. units in Fig. 6 (apparently overlooking the fact that the arc velocity was, in fact, expressed in the C.G.S. unit).

Mr. C. J. O. Garrard had built an air circuit-breaker with chutes many years ago but hardly claimed that it was a true free-air circuit-breaker in that he had used compressed air to transfer the arc to the runners. This was necessary in interrupting small currents, although it was not required at higher currents. Like other speakers, he wondered why people were developing free-air circuit-breakers, seeing that the oil circuit-breaker was a well proved device.

The authors replied very competently to those matters in the discussion which concerned the substance of the paper. They did not explain, and we went away still wondering why anybody is developing air-break circuit-breakers anyway.

J. L. E.

Ce soir de fête

Judged on the demand for places, the Section Dinner-Dance is always assured of success, but numbers alone do not give a true measure of its popularity. The atmosphere of warm friendliness which has been the prevailing characteristic in

The Supply Section Dinner-Dance—a 'bunch' of Chairmen

Left to right: Mr. G. Millington (Electronics and Communications Section); Mr. R. A. Marryat (Utilization Section); Mr. D. P. Sayers (Supply Section); Mr. J. K. Webb (Measurement and Control Section)

the past was again strongly in evidence at the Connaught Rooms, London, throughout the evening of the 11th March 1959. In the early part, the Chairman, Mr. D. P. Sayers, with Mrs. Sayers, received the President and Mrs. Goodall, the Chairmen of the other Sections and their ladies, and members and guests totalling nearly 400.

An excellent repast was terminated in the accepted traditional manner—that on such occasions the immediate postprandial activities in the form of speeches should be brief. In welcoming the guests the Chairman faithfully observed this injunction, but courtesy was not sacrificed for the sake of the self-imposed brevity. Referring to the guests at his table he had some difficulty in finding a suitable collective noun to describe a group of Chairmen and hovered between the choice of a 'platform' and a 'bunch'. Nevertheless, in welcoming them and extending warm greetings to an ex-Chairman of the Supply Section, Mr. Goodall, Mr. Sayers most certainly made it clear that he was happy to have all the visitors present.

The President responded to the welcome accorded the guests and said that he found himself among friends—old friends. With extreme diplomacy he indicated that he obviously could not draw comparisons between the superlative virtues of the various Sections. But considering that his present position precluded him from showing any leanings which he might possess, he did leave an impression of the direction in which his feelings had their bent.

Dancing commenced shortly afterwards, and even the most seemingly staid and respected members of the profession disported themselves with obvious enjoyment and a verve comparable with that of the younger members. The remainder of the evening slipped by in a succession of modern and not-so-modern dances, involving in many cases considerable expertise, or simply in pleasant discourse between those less active.

All too soon it became time for carriages (or should one simply say 'cars'), and a highly successful and happy occasion had ended. F. C. W.

ELECTRONICS AND COMMUNICATIONS

High-current-density emitters

THE subject of thermionic emitters for valves tends to be taken somewhat for granted, until an unusual application, such as the repeaters for a submarine cable, serves to pinpoint the absolute dependence of progress in electronic activities on steady advances in this field. A paper entitled 'High-current-density thermionic cathodes: a survey' was read by Mr. A. H. W. Beck at Savoy Place on the 19th January 1959.

Mr. Beck's paper, which is reviewed on p. 307, performed an admirable service in directing attention to the considerable progress which has been made in an important part of this subject, that of high-current-density emission, i.e. a continuous emission density above 1 A/cm^2 with a life longer than several hundred hours.

The spectacular progress in a wide range of devices particularly suited for operation at the shorter radio wavelengths has continuously maintained the pressure to provide high-current-density emitters, these being usually required also to have the ability to withstand high electric fields. Two main types have emerged, both of the dispenser design, in which long life is achieved by incorporating a relatively large amount of emitting material within a metal matrix of either nickel or tungsten.

A very interesting account of the numerous forms and varieties of both was given by Mr. Beck. Some of the techniques of research into the more fundamental aspects of operation were described and explanations of the mechanism of operation developed. Considerable attention was also given to many aspects of the preparation, processing, operation and performance of the bariated-nickel cathode, which has been the object of the author's special study for a number of years.

The present state of the field may be deduced from the statement made by the author that both basic types of cathode should result in lives in excess of 20000 hours at densities of 1–2 A/cm^2, the limit being usually found in heater performance.

As was to be expected, a specialized meeting on the subject of cathodes and emission evoked a most lively and interesting discussion, particularly since the final reference by the author to the spending of 'several years of hope, pleasure and exasperation' on work in this field struck a familiar ring to several of those present. A wide range of points were raised, from questions (beloved by cathode people) whether the undoubted advantage of one cathode or another was not due to the method of assessment used, to the mechanical problems of using such improved cathodes for valves with very close clearances.

In winding up the discussion, the Chairman, Mr. G. Millington, said he thought that this specialist meeting had been of just the type which it was particularly desired to encourage. W. E. W.

New amplifying techniques

THOSE of our members not intimately concerned with the subject have perhaps been a little baffled by the recent rapid growth of a new field of amplification, in which strange new words such as 'maser', 'mavar' and 'mesa' are used with gay abandon by the initiated and apparently without any significant confusion. Mr. C. W. Oatley, at Savoy Place on the 18th March 1959, was completely successful in presenting to an appreciative audience an understandable account of the new principles, without allowing any suggestion of mystery to appear. He divided his field into two classes: parametric amplifiers and masers.

Parametric amplifiers

Dealing first with parametric amplifiers, a subject with which Lord Rayleigh also had some acquaintance, Mr. Oatley showed how, by suitable timing of mechanical displacements of the condenser plates, the damping of the simple *LCR* circuit may be reduced by the transformation of the mechanical energy at the frequency of displacement of the

condenser plates (the 'pump' frequency) to electrical energy at the resonant frequency of the circuit (the 'signal' frequency). The same effect could be obtained by purely electrical means using a condenser whose capacitance could be varied electrically.

These arrangements involved a pump frequency which was a multiple of the signal frequency; however, by coupling an extra resonant circuit, called the 'idler', of frequency equal to the difference between pump and signal frequencies, to the signal circuit by the variable condenser, energy transformation from pump to signal, or idler, frequency could be obtained with different frequency relationships. In addition it now became possible for an amplified version of the signal frequency to appear at the idler frequency, so that, depending on the exact frequency relationship, an 'up' or 'down' convertor could be derived.

Mr. Oatley then considered the practical achievement of the necessary variable reactance. A ferrite (yttrium–iron garnet) operated at its ferromagnetic resonance frequency could be used, though at present high pumping powers are required. A semiconductor p–n junction also formed a very convenient variable capacitor; by variation of bias the spacing between the effective electrodes inside the material could be varied. An electron beam could be used, since the reactance presented by it to an electric field region depends on its transit time through the field.

The maser

While the parametric amplifier could be analysed entirely on the basis of classical electromagnetic theory, the maser invoked quantum-mechanical concepts involving energy levels and population distribution.

In gases or solids (liquids were not excluded) equilibrium involved groups of particles in a number of discrete energy levels, with the populations of the higher levels less than those of the lower. Energy may be generated by allowing particles spontaneously to change energy from one quantum level to the next lowest one, provided that the equilibrium conditions are suitably disturbed. The frequency generated is proportional to the difference between the energy levels. This disturbance may be achieved either by physical separation of the equilibrium populations of two energy levels, or the populations themselves may be redistributed so that higher energy levels have higher populations.

In the earliest form of maser, the ammonia maser, gas molecules of energies having an effective frequency difference of 23·9Gc/s were separated by passing them through suitable electric fields. The higher-energy molecules were allowed to pass into a high-Q resonator tuned to this frequency, where energy was radiated in changing to the lower energy level. A power of 10^{-10} watt could be radiated, which could be used either for amplification of a signal applied to the resonator or, with reduced damping, as a highly stable self-oscillator.

A paramagnetic substance placed in a steady, uniform magnetic field exhibits a number of discrete energy levels. These levels, and thus the frequencies associated with them, may be changed by varying the applied magnetic field. In order to reduce internal losses in the material, a small amount of the active paramagnetic substance is dispersed in an inactive isomorphous crystal. Operation is at low temperature, obtained by cooling to liquid-helium, or possibly only to liquid-nitrogen, temperature.

In one form, three energy levels are used, and irradiation of the material with a 'pump' frequency equal to the difference between the frequencies of the top and bottom levels increases the population of the top state, with consequent redistribution of populations between top and middle state and final emission of radiation from middle to bottom state.

Comparisons

Turning to some general comments on these new amplifiers, Mr. Oatley pointed out that, though both types were tunable, parametric amplifiers were essentially much more broadband than masers, though there was no fundamental reason why the latter should not be exploited to much higher frequencies than had been so far achieved with coherent generators.

Among the parametric amplifiers, the ferrite type, temporarily eclipsed, could well appear again after further research, and he thought that the solid-state diode would be likely to beat the beam in the frequency race, at least up to 10Gc/s. A good low-noise diode amplifier had already been achieved at 6Gc/s. On the other hand, the parametric beam amplifier held out strong hopes of a noise factor less than that of the more conventional low-noise beam amplifier (and this was already very low).

This led to the question of what noise performance is required. In the particular field of radio astronomy where a very-narrow-beam aerial can be directed to the low-noise source of outer space, the maser with its very low noise factor can be used to full advantage. In the more usual fields of communication, the noise background may be much higher, and the advantages of bandwidth and convenience of parametric amplifiers may be exploited to the utmost, since the noise performance is adequate.

In conclusion, Mr. Oatley urged that the maximum amount of research should be put into these new amplifying techniques, particularly the maser field. The maser principle, with its controllable use of spontaneous radiation, represented one of those rare steps in the evolution of science where an entirely new fundamental principle is successfully applied to the solution of a long-standing problem. It had certainly laid the foundations for an entirely new line of advances and justified all possible research effort.

Discussion

The discussion, which was opened by Mr. L. Lewin, showed how wide had been the interest created by this lecture. Many topics were covered, ranging—quite apart from the serious engineering aspects of the subject—from the importance of the children's playground in the checking of basic scientific principles, to the process, random or otherwise, by which chemical substances are chosen to provide the required physical constants for making use of a new fundamental principle.

Among the points aired was the coherence of the output signal of a maser amplifier and in particular the relation between the phases of output signal and of low-level input signal. The problem of providing the pump signal for a maser amplifier operating at the highest frequencies was also mentioned. The amplitude/phase characteristics of the wide-band parametric amplifiers were discussed, as were the effects which might be produced by high-signal-level operation. On beam devices a physically attractive description was given of the way in which noise could be removed from a beam in preparation for use in a parametric amplifier.

The meeting concluded with the Chairman, Mr. G. Millington, expressing to Mr. Oatley on behalf of all those present his appreciation of the faultless way in which this important subject had been presented. W. E. W.

Geoelectric surveying

On the 3rd February 1959, Mr. J. K. Webb was in the chair when members of the Section were taken to the border of electrical measurement and were shown, by Prof. L. S. Palmer, the science and art of geoelectric surveying. A short article based on Prof. Palmer's paper appears on p. 300.

To make members feel that this was not so very remote from the more common electrical measurements, he explained that in this technique the earth or ground is regarded as a 4-terminal resistor or potentiometer—albeit a three-dimensional one. Four electrodes are placed in the ground spaced along a straight line; the inner pair—the potential electrodes—are spaced symmetrically about the centre of the current electrodes.

For a given configuration of the electrodes, the current distribution in the ground and the potential distribution at the surface are functions of the resistivity below as well as at the surface; the further apart the electrodes, the more the apparent resistance measured at the surface depends on the resistivity at a greater depth. Prof. Palmer explained how a graph of the measured variations of resistance with change of electrode spacing is used to infer the underlying geological structure and how the depth of a transition from one stratum to another can be estimated if they have different resistivities. Where the individual strata can be identified, by reference to a borehole for example, they can then be surveyed by means of a systematic series of geoelectric measurements.

A brush with the police

The first area to which Prof. Palmer conducted us was the Holderness Plain between Hull and Bridlington, where the survey was carried out smoothly enough and the results agreed with the geological information available. However, it was not without its unexpected risks. Measuring near a gas works one day, with a member of the team cranking the hand generator, they were nearly arrested by the local constabulary. (It was at the time of the I.R.A. episodes.)

Prof. Palmer mentioned the location by geoelectric survey of a cavity under an airfield runway, which, had it not been found, might have caused a serious accident if a heavy aircraft had landed on top of it.

He went on to describe graphically how they had located and mapped from the surface the reputed Pen Park Hole, near Bristol; this had been sealed, so the story runs, after a canon of Bristol had fallen to his death nearly 200 years ago. By making numerous traverses they built up an accurate plan of the cavern and its entrance tunnel. (Two men who had pleaded to be allowed to go down with them and continue exploring proved to be escaped convicts wanted by the police.)

Prof. S. K. Runcorn, opening the discussion, compared geoelectric with two other methods of geophysical surveying—magnetic and gravitational. The two last were mainly of use in delving deeply into the earth's crust, while the geoelectric method was restricted to strata near the surface. In all the methods there was the difficulty of inferring the geological structure from the variations in the observed phenomena. Geoelectric surveying had the advantage that a picture in depth could be drawn.

Mr. J. H. Morgan described the application of a two-dimensional laboratory model to obtain curves of resistivity versus electrode spacing which matched the curves obtained from the field measurements. This simple technique did not depend on the theoretical mathematical analysis of Prof. Palmer's method, and it had been tried out successfully at Tor Marsh on Dartmoor.

Liable to errors

Dr. H. H. Shaw, speaking as a visitor and geologist, showed some surprise that more prominence had not been given to the success of the original Wenner method, particularly for locating water boreholes in Africa. He was also critical of the reliance placed on a mathematical interpretation of the data, which may lead to erroneous results; he considered the water-table shown in a diagram of a Mendip survey was impossible, as a line of springs was shown at its highest point.

Mr. E. J. Leaton showed a variation of the basic circuit in which the detector was phase-sensitive. Mr. F. C. Widdis emphasized the care and foresight required in designing field equipment, giving as an example some geophysical prospecting apparatus which was sealed for use in dry dusty atmospheres but in which trouble was, in fact, caused by condensed moisture within the case. It cost a large sum to send a man out to find a cure: this was simply to wipe the panel dry and to instruct the operator to repeat the process when necessary.

Post Office surveys

The widespread geoelectric surveys carried out by the Post Office were mentioned by Mr. A. C. Lynch. These were made to estimate the danger to telephone circuits of an earth fault on nearby power circuits. The induced voltages, he explained, would be greatly dependent not only on the earth current but also on the path it took in relation to telephone circuits.

In reply, Prof. Palmer agreed that his method was more appropriate for shallow and moderate depths; the difficulty of detection, he remarked, varies as the cube of the depth. Commenting on Mr. Leaton's method and some observations of Mr. Widdis, he admitted having tried apparatus in the laboratory using alternating current, but there had been considerable difficulty on account of phase shifts, which he had avoided in his method by using slowly-reversed direct current.

A varied and interesting meeting was concluded by a vote of thanks proposed by the Chairman and passed with acclamation.

G. H. R.

Electricity meters

On the 3rd March 1959, Mr. L. B. S. Golds took the Section back to have a new look at the toys of its infancy—electricity meters—and demonstrated how much there was still to learn about their proper use. It is unfortunate that a statistical approach to any subject seems inseparable from a repellent title, since otherwise many Supply Section members might well have swelled the good audience which a meter topic always attracts. A review of the paper, which is entitled 'The influence of consumers' load/consumption characteristics on metering practice', appears on p. 302.

Bearing in mind the Section Chairman's recent exhortations, the author's opening remarks were in appreciably lighter vein than his subject portended, but this seemed to

emphasize his points. Having first established the vital role of meters in electricity supply and noted the enormous annual revenue they determine, he came directly to the economic problems posed by the cost of meter maintenance, the loss of revenue caused by neglect, and the possible unnecessary cost to the consumers imposed by over-rigorous legislation.

Prevalence of over-metering

The paper was concerned with the conclusions to be drawn from the results of four investigations into the proportions of domestic-consumers' consumption taken at various bands of load, this being rendered possible by a load-analysing meter designed by the author for the purpose. Noteworthy points were the surprisingly large proportion of the consumption taken at low loads, the relatively small maximum demands resulting from quite appreciable installed loads, and the prevalence of over-metering.

Mr. Golds also quoted the measured errors at low, medium and high loads of the service meters concerned in the four investigations. These confirmed general expectations that very few meters indeed over-register and that with increasing age a large percentage under-register at low load values.

The author then proceeded to develop a method of calculating the point in time at which it is economic to recondition meters. To do this he needed a figure for error of total registration, which he was able to produce using his acquired knowledge of the distribution of consumption at various loads. It was interesting that in a typical case this economic service period was 24 years. Mr. Golds extended his method to consider a suitable legal re-service point.

Revision of meter ratings

The very reasonable claim was made that the results of the work established a case for revised British Standard meter ratings, and the possibility of a single meter rating for domestic consumers was put forward.

In the ensuing discussion there was some controversy between participants which touched on the ethics of selling electricity. There were, as usual, requests for more information, which the unfortunate author, confined as he is by Institution rulings on space, would already have given gladly had he been able.

Altogether, it would not be an overstatement to call the evening a personal triumph for Mr. Golds, who, having worked away at his subject under difficulties for many years, must have felt great satisfaction at the way in which his paper was received. H. S. P.

Electrical uses of atomic spin

Atomic spin is considered by most electrical engineers to be a specialized field, of interest only to the atomic physicist. The informal lecture given by Mr. G. Phillips on this subject at Savoy Place on the 17th March 1959 made it clear that the use of this phenomenon will become an important and comparatively simple technique in electrical measurement.

The chair was taken by Mr. J. K Webb, and Mr. Phillips opened his discourse by explaining that the tiny particles which constitute the atom have angular momentum or spin. Since these spinning particles are electrically charged, they exhibit magnetism as if they were tiny compass needles, and they are therefore sensitive to external magnetic fields.

When a sample of water is placed in a magnetic field, a torque is exerted only on those protons which are hydrogen nuclei. The torque causes the spinning protons to precess around their local magnetic field H_L, with a frequency ω known as the Larmor frequency, given by $\omega = \gamma H_L$, where γ is a constant termed the gyromagnetic ratio and is $2{\cdot}675 \times 10^4$ for protons. The precession of the magnetic moment induces an alternating e.m.f. in a surrounding coil, and the frequency of this e.m.f. provides a measure of the external field.

Frequency can be measured with a very high accuracy, and the constant γ is known to within about 1 part in 10^5; hence this phenomenon has led to the development of a number of very accurate and sensitive magnetometers, primarily for measuring the earth's magnetic field. The sensitivity of the method is such that it can be used for locating buried objects by virtue of the distortion produced by them in the local magnetic field. It has been used very successfully for archaeological surveys and for locating underground water. Other interesting applications include the exploration of the Atlantic sea-bed and oil prospecting by aerial geomagnetic survey.

A bottle on a pole in Hampshire

At this point Mr. Phillips gave a most elegant demonstration of the measurement of the earth's magnetic field. A bottle of water mounted on a pole, in a field at Christchurch, Hampshire, was magnetized by a suddenly applied field, and then the protons were allowed to precess in the earth's magnetic field, inducing a decaying exponential voltage wave of a few microvolts' amplitude in a pick-up coil. The signal was transmitted over a telephone line and displayed on a cathode-ray oscillograph in the Institution Tea Room; measurement of the signal frequency gave a measure of the earth's magnetic field at the position of the bottle.

The demonstration illustrated the manner in which such field measurements could be carried out at a central station remote from the test position. A high degree of uniformity in the field is necessary for this method to work. A razor blade in the vicinity of the bottle obliterates the response; it is therefore impossible to carry out this demonstration, with the bottle in the London area, because of the disturbances caused by iron-framed buildings.

The detection of unpaired electrons is of considerable importance in the biological and medical fields, since they indicate the presence of very reactive substances. The magnetic moment of the electron is about 660 times that of the proton, and the precession frequency is in the microwave region. Nevertheless, such techniques have been used to show the presence of free electrons in cigarette smoke.

If a small rotating magnetic field at the frequency of precession is applied in a plane at right angles to the main field, power is absorbed from the rotating field. This phenomenon is known as electron-resonance absorption. The absorption due to the large number of unpaired electrons in ferromagnetic materials has led to their use as one-way transmission devices in waveguides; a useful material for this purpose is the yttrium garnet ferrite. A modification of this technique gives an increase in power and has led to the design of very-low-noise amplifiers, known as masers.

Mr. Phillips was extensively questioned by those present on details of the applications described. He must be congratulated on the masterly manner in which he held the interest of his audience; this was probably one of the most interesting and enjoyable evenings we have had. The vote of thanks moved by the Chairman was well merited. F. C. W.

News from the Centres

NORTH MIDLAND CENTRE

The Deltic locomotive

On the 3rd March 1959, in accordance with established tradition, a joint meeting of the main Centre and the Sheffield Sub-Centre was held in Wakefield, at which 78 members and visitors were present. The Centre Chairman, Mr. J. D. Nicholson, expressed his pleasure at once more seeing the Sub-Centre at a combined meeting. He then handed over to the Sub-Centre Chairman, Dr. F. A. Benson.

In thanking Mr. Nicholson for inviting the Sub-Centre to what is always regarded as a highlight of the year, Dr. Benson remarked that such a meeting was valuable for getting to know new faces and for the opportunity of discussion with friends in the main Centre. He introduced Mr. W. G. Jowett, who had agreed to read Mr. C. M. Cock's paper on 'The *Deltic* locomotive' in the author's absence owing to illness. A short review of the paper appeared in the March 1959 *Journal*, p. 155.

Mr. Jowett gave an interesting résumé of the paper, which was followed by a very general discussion answered by him in great detail and with an obvious full knowledge of the subject. In proposing a vote of thanks to Mr. Jowett, Mr. Nicholson considered that the *Deltic* locomotive would make a substantial contribution to the reorganization of British Railways.

W. J. W.

NORTH STAFFORDSHIRE SUB-CENTRE

A lucid exposition

In presenting his paper on 'Operational experience at Calder Hall' to the meeting held at Stoke on the 16th January 1959, Mr. K. L. Stretch mentioned that the flexibility of operation of the station had proved to be greater than expected. (A review of the paper appeared in the July 1958 *Journal*, p. 390.) Although working up from the fully shut-down condition is slow, load changes between 15% and full load can be effected extremely easily and quickly. This is a valuable feature from an operational point of view, but of course the economic requirement of running at a high load factor as a base-load station still holds good because of the high capital cost of nuclear stations.

The description of the methods adopted in commissioning this first commercial nuclear power station proved of great interest, and a number of members joined the discussion opened by Mr. V. J. Vickers. Mr. J. A. P. Firth, proposing a vote of thanks to the author, congratulated him on his lucid exposition of the problems involved and their solution.

A bird's-eye view

Following the revision of boundaries by which the Sub-Centre lost Burton upon Trent in the south but gained an area centred on Crewe in the north, the first District Meeting at Crewe was held on the 21st January 1959 and was attended by about 20 members and a large number of the students taking the electrical engineering course at the Technical College. Mr. R. W. Palmer welcomed the Crewe members to the North Staffordshire Sub-Centre and thanked Mr. MacMasters for allowing the students to attend. He then delivered his Chairman's Address entitled 'Electrical engineers and electronics', in which he surveyed the history of electrical engineering. An article based on the Address appears on p. 280.

Mr. A. Asbury proposed a vote of thanks to the Chairman and suggested that it was good for engineers to sit back at times and take a bird's-eye view over the whole field of electrical engineering, past and present.

Mr. Palmer then invited the members to submit their views on the arrangements for future meetings and the type of papers to be read. After discussion it appeared that the majority favoured periodic meetings at Crewe starting at 7.30 p.m. to allow time for more distant members to arrive. Mr. D. J. Andrews, Honorary Secretary of the Graduate and Student Section, welcomed the Graduates and Students and invited them to take an active part in the Section activities. Among other proposals discussed was a suggestion by one Crewe Graduate that a visit to a nearby electrical engineering works might prove useful.

Annual Dinner

The Annual Dinner, held at the Crown Hotel, Stone, on the 20th February 1959, again provided the opportunity for members to meet socially in the pleasant and not too serious atmosphere which usually attends this function. Following the loyal toast, the Chairman indicated something of the anxiety he and the Sub-Committee had felt regarding the arrangements as, only four days before, one of the principal guests, Mr. T. A. Beardsmore, headmaster of Alleyne's Grammar School, Stone, had indicated that he was ill and expected to go into hospital almost immediately. Mr. Palmer was therefore very pleased to announce that his friend, Mr. Tom Wilson of the *Stone Guardian*, had accepted his invitation to respond on behalf of the guests.

Still later, a message was received from another principal guest, Mr. R. J. P. Harvey, Deputy Director-General at the Post Office Headquarters, that he was in America on business and likely to be held up by fog. Fortunately, however, the Comet rose to the occasion and Mr. Harvey arrived in time. Our other principal guest, Sir Hamish MacLaren, a Vice-President, and Director of Electrical Engineering at the Admiralty, apparently had not given any cause for anxiety.

In a witty and amusing speech, Mr. Harvey proposed the toast of The Institution. Although not an engineer himself, he had come to associate a warmth of friendship with all his dealings with engineers, whether they were his friends, colleagues or contractors' representatives whom he met in the course of his administrative work with the Post Office. He spoke highly of the work of Post Office engineers and electrical engineers generally throughout the country.

He regretted he had not yet achieved his ambition to become a Companion. He thought this was given as a reward for service to The Institution, but as he had had to place some restriction on the rate of development of the telephone service he thought he was more likely to be considered a menace than a help. Also, as he was a Scot, some little difficulty arose, as he understood he would be required to pay a substantial fee.

In responding to the toast, Sir Hamish MacLaren thought

that, if the financial barrier could be overcome, Mr. Harvey should have little difficulty in achieving his ambition. He said The Institution made heavy demands on its Vice-Presidents, but he 'grudged least of all' the time spent visiting Centres and Sub-Centres and increasing the range of his friends in The Institution. He referred to the work done by the Chairman, Committee and Officers of the Sub-Centre and was specially delighted to see the strong Graduate and Student Section. He stressed that greater efforts must be made to interest the rising generation in electrical engineering and to raise the status of engineers in society. He said it rested with all of us to do everything possible to enlighten the public.

Mr. A. Asbury, Vice-Chairman of the Sub-Centre, proposed the toast of the guests entirely in verse. As our last meeting had taken the form of a discussion on 'What is a cultured engineer?', Mr. Asbury thought 'poetry would help if culture you seek'. He said Mr. Harvey had 'nothing to do with the manners of counter assistants on stools when you get postal orders on Thursdays for pools' and Sir Hamish MacLaren's 'subs give him more trouble now than you might think for there are no depths to which they will not sink'. Regarding—

'Mr. Wilson of the *Guardian*, a stalwart of the Press,
Comes readily to rescue, this we must confess.
I'd like to say how pleased we are to have him here tonight,
We'll have to buy more papers now to see that he's all right'

and more generally 'Our Press is very helpful, it highest thought inspires, and then, as if to cap the lot, they help to light our fires'. All our guests received tribute in similar form.

Mr. Wilson, responding, and referring to himself as a substitute, said 'I do not know whether you are satisfied—I am terrified' and proceeded in a very amusing and racy speech to show how untrue that was. He enlivened his speech with many anecdotes relating to the Navy and the Post Office and then in more serious vein appealed to engineers to stop and think occasionally on what we are liable to lose if we allow automation to develop too far and to enter too closely into our lives. It would be a pity if we lost our humanity and those personal relationships which he summed up as 'the Nelson touch'.

L. G.

District Meeting at Douglas, I.O.M., 6th March 1959

MERSEY AND NORTH WALES CENTRE

Faraday Lecture

As he is a former member of the Centre Committee, there were many old friends to welcome Dr. H. A. Thomas on his visit to present the Faraday Lecture in Liverpool at the Philharmonic Hall on the 26th February 1959. For good measure he delivered it twice, giving a matinée performance principally for the benefit of senior students from grammar and technical schools. The audiences were highly appreciative, applauding enthusiastically the demonstrations that made special appeal.

P.V. Hunter Memorial Lecture

The first of these lectures was delivered on the 2nd March 1959 in Liverpool at the Royal Institution by Mr. C. O. Boyse. Many of the references made in the course of the historical survey of the technical development of the industry and to the part played by P. V. Hunter brought back, to at least some of the audience, glimpses of the past: the split-conductor system used by one of the local undertakings; the buoyant cables of the recent war on their distinctive outsize drums; and P. V. Hunter himself taking part in the annual Centre golf tournament.

District Meeting

The second District Meeting in the Isle of Man since its incorporation into the Centre was held on Friday, 6th March 1959 at the Fort Anne Hotel, Douglas, and was attended by Mr. J. Collins, Chairman, and Mr S. Towill, Honorary Secretary. The proceedings took the form of an abridged version of his Chairman's address by Mr. Collins and an informal lecture on 'Atomic power' by Mr. C. Anderson, Borough Electrical Engineer of Douglas, who convened the meeting.

These visits have been greatly appreciated by the civic authorities as well as by our resident members. On this occasion, the visitors included four members of the Douglas Corporation Electricity Committee—Alderman R. F. Quayle, J.P., Chairman, and Councillors J. E. Callister, T. A. Corkish and W. A. Moore; Councillor Corkish is a member of the House of Keys. Also present were the Town Clerk, Mr. D. N. Blakey, and the Borough Treasurer, Mr. A. Costain. The Isle of Man Electricity Board were represented by Mr. J. W. Callow and Mr. S. Clucas.

Annual dinner-dance

This most popular of our social functions was held at Hulme Hall in the model village of Port Sunlight on Friday,

Mersey and North Wales Centre dinner-dance, Hulme Hall, 13th March 1959.

The Chairman and Mrs. Collins receive Mr. and Mrs. G. R. Harding

13th March 1959, when 260 members and friends defied superstition to their advantage and enjoyment. Mr. J. B. Lancaster again undertook the duties of M.C., and Miss Jane Lancaster presented a bouquet to Mrs. Collins. In accordance with custom, a competition was held for the benefit of the Institution Benevolent Fund, which thereby benefited to the extent of nearly £60.

Annual General Meeting

At this meeting in Liverpool on Monday, 6th April 1959, Mr. T. A. P. Colledge was elected Chairman and Mr. R. N. Pegg Vice-Chairman for the 1959–60 Session.

Institution Prizes based on the award of the Higher National Certificate and Diploma in Electrical Engineering were presented to Messrs. L. J. Harvey, G. A. Lee, A. G. Littler and J. S. Roberts.

At the Ordinary Meeting which followed, Dr. P. T. Standring gave his lecture 'Artificial fibres'. (A summary of the lecture appeared in the July 1958 *Journal*, p. 413.) This proved to be most interesting, with numerous demonstrations, and the lecturer provided a comprehensive display of finished products which one almost felt diffident about examining too closely. E. W. A.

SOUTHERN CENTRE

Annual Dinner and Dance

THE Southern Centre includes among its members a good proportion of electrical engineers who are naval officers or engaged on research for naval projects. It was appropriate, therefore, that the chief guest at the Annual Dinner and Dance held at the Polygon Hotel, Southampton, on the 18th December 1958 was Rear-Admiral J. H. Unwin, D.S.C., Admiral Superintendent of H.M. Dockyard at Portsmouth. He proposed the toast of The Institution most wittily and spoke of the penetration of electricity into every aspect of life ashore and afloat.

The Centre welcomed the President, Mr. S. E. Goodall, and the Secretary, Mr. W. K. Brasher. Also present at the Dinner were Mr. F. L. Wooldridge, Chairman of the Southern Association of Civil Engineers, and Col. Chattock, Chairman of the Southern Branch of Mechanical Engineers.

E. A. L.

Annual Dinner and Dance of the Southern Centre

Shown here are Mr. W. K. Brasher; Rear-Admiral J. H. Unwin; Mr. S. E. Goodall; Mr. A. Roby, Honorary Secretary of the Graduate and Student Section; Mr. G. Bishop, Chairman of the Southern Centre; Mr. R. J. Barnard, Chairman of the Graduate and Student Section; and Mr. W. H. Housley, Honorary Secretary of the Southern Centre; together with their ladies

SHEFFIELD SUB-CENTRE

Successful week-end conference

IN 1958 the Sheffield Graduate and Student Section had the good idea to hold a week-end conference, and they had the initiative and drive to put their idea into effect and to make a success of it.

On the 28th February and the 1st March 1959 they held a further week-end conference, already regarded as an annual event. This conference was even more ambitious and successful than its predecessor.

The programme included two technical visits, three 'ordinary' meetings with presentation of papers and discussions, and the showing of three films (one of which provided comic relief at the end of the Saturday's proceedings). The two visits were to Ringway Airport and to the North-Western Electricity Board's testing works at Stalybridge. The remainder of the conference took place at Buxton. The three papers were: 'Instrumentation', by P. N. Baker and D. B. Copley; 'Electronic organs', by P. M. Chalmers; and 'Pressure-assisted cables', by J. F. Johnston.

Attendance, the best possible 'barometer' of the popularity of meetings, was higher than the average of any ordinary session, being 39 on the Sunday.

Faraday Lecture

In Sheffield we have the advantages of the fine City Hall and an exceptionally interested and appreciative audience; and these assets, together with excellent lecturers, ensure a most successful event whenever there is a Faraday Lecture.

'Automation', by Dr. H. A. Thomas on the 6th March 1959, was no exception. An article describing the Lecture

appeared in the March 1959 *Journal*, p. 147. The audience of 300 were fascinated, and at the end most enthusiastic in their applause.

The Sub-Centre was again honoured by the presence of the Lord Mayor of Sheffield, Alderman J. W. Holland, J.P. This was the second meeting of the session attended by Alderman Holland. The vote of thanks was proposed by Prof. Quarrell, Pro-Vice-Chancellor of the University of Sheffield.

North Lincolnshire District

There have been two meetings during 1959, both testifying to the healthy state of the newly formed North Lincolnshire District and to the enthusiasm of its Convener, Mr. H. Peace. On the 16th February 1959, the District was addressed by Mr. J. D. Nicholson, Chairman of the North Midland Centre. On the 16th March 1959, three short papers on electrical maintenance were presented by members of the District. The attendance on this occasion was over 80. F. G. T.

SCOTTISH CENTRE

Edinburgh dinner

ONCE again an attendance of over 170 at the Edinburgh dinner on the 19th March 1959 almost burst the seams of the Adam Rooms; Mr. R. J. Rennie, Chairman of the Centre, presided over an event noteworthy for its general good-humour and the joyful character of all the speeches.

Unfortunately the chief guest, Vice-Admiral J. D. Luce, was prevented by illness from being present, but his Chief of Staff, Captain A. J. F. Milne-Home, R.N., following true naval tradition, stepped into the breach at very short notice and proposed the toast of The Institution. Capt. Milne-Home, who has specialized in gunnery, referred to the many developments that have taken place in electrical gun control; he also mentioned certain 'electrical idiosyncrasies' that he had met, but was chided by a later speaker, Mr. R. B. Anderson, for having put into the mind of The Institution a possible new subject for its Examination.

The President replied with a very amusing speech and expressed the pleasure felt by himself and Mrs. Goodall at being again in Scotland. The Chairman then had the privilege of calling on his son, Mr. R. M. Rennie, Chairman of the South-West Scotland Graduate and Student Section, to speak on behalf of the Graduates and Students. Mr. Rennie, Jun., after suggesting that 'two Rennies' would be an infallible cure for any indigestion that his speech might cause, gave a very encouraging report from all three Graduate and Student Sections; and it was subsequently remarked by Mr. Brasher that if all the Graduate and Student Sections could give similar reports, many of the worries of The Institution in this connection would cease.

Mr. Anderson, Past-Chairman of the North Scotland Sub-Centre, proposed the toast of the guests, to which Mr. C. M. Wilson, Vice-Chairman, Institution of Civil Engineers, East of Scotland Association, replied. Finally, Mr. J. Mendelson, Chairman of the South-East Scotland Sub-Centre, proposed the toast of the Chairman, referring particularly to Mr. Rennie's well known characteristic of paying close attention to detail, which is proving so valuable to the Scottish Centre. Mr. Rennie's reply ended another most enjoyable function—even our hard-working and indefatigable Honorary Secretary, Mr. J. H. P. de Villiers, was satisfied, because, for the first time in history, the function had finished before his scheduled time—by 47·3 seconds.

Automation

The last disc dropped into its appropriate bin, the last doughball was projected across the stage, and the computer recorded the last addition on its giant tape when Dr. H. A. Thomas gave, at the Usher Hall in Edinburgh on the 24th March 1959, the 13th and final presentation of this session's Faraday Lecture. Rumours had got around that the demonstrations and stagecraft accompanying the Lecture were to be on an unprecedented scale, and the record audience, including many from the Edinburgh Schools Scientific Society, were in no way disappointed; adjectives more usually associated with the spectacular productions at the nearby cinema were heard as the crowd subsequently emerged into the street.

More serious consideration of the prospects outlined by Dr. Thomas seemed to many, however, to be somewhat frightening, and one could not help wondering whether the world is yet ready for automation on the scale described in the latter part of the Lecture. The thanks of the audience were expressed by Dr. D. S. Imrie, Rector of the Royal High School, and their applause left no doubt of their appreciation of Dr. Thomas's monumental effort in presenting a very difficult subject so clearly. E. O. T.

News from abroad

TRINIDAD AND TOBAGO JOINT GROUP

Flight simulation

MR. W. T. Boyd, M.I.MECH.E. (Vice-Chairman) took the chair at our last meeting, when Mr. G. Machin, GRADUATE I.E.E., presented his paper 'Flight simulation as an aid to aircraft design'. Mr. Machin gave an admirable outline of the use of analogue computers in simulating flight conditions on a purely theoretical design of aircraft and explained how computers can also be used to study modifications to existing aircraft long before the modifications are actually carried out. His paper was well illustrated by block diagrams showing the equipment used, and an interesting discussion ensued.

After the paper and suitable refreshment, two films were shown: 'Jet lift' (the story of the Flying Bedstead) and 'Farnborough—1958', both of which, lent by the United Kingdom Information Office, were very much appreciated.

The meeting was held at Pointe-à-Pierre Club, and ample opportunity was available for members to get together both before and after. This enabled us to meet our two latest members, Mr. E. Taylor, A.M.I.E.E., and Mr. E. A. Mbiwan, A.M.I.E.E., both newcomers to Trinidad. We have also been pleased to extend a welcome to another newcomer, Mr. J. D. Williams, A.M.I.C.E. D. P. J. H.

MIDDLE EAST JOINT GROUP

Contracting problems

THE Group held its second meeting of the 1958–59 Session on the 5th and 6th March 1959 in Kuwait.

The Chairman, Mr. L. J. Cotterill, A.M.I.MECH.E., M.I.E.E.,

informed the members that our Immediate Past-Chairman, Capt. J. M. Morris, O.B.E., A.M.I.MECH.E., M.I.E.E., had died at his home in Basra on the 3rd February. With the passing of Capt. Morris the Group has lost one of its founder-members. A one-minute silence was observed in respect.

The paper presented at the meeting by Mr. Faiz Boustany, A.M.I.C.E., was entitled 'Some problems of a widespread contracting organization in the Middle East'. This paper analysed the mounting demand for contractors in the Middle East and the diversification and extensive nature of their work. It also discussed some of the problems involved. There was an interested audience of some 53 members and guests, and the paper was followed by a lively discussion.

After the meeting an enjoyable buffet supper was provided at the Ahmadi Guest House.

New harbour

On the following day some 50 members and guests visited the new harbour facilities presently being constructed for the Public Works Department of the Government of Kuwait. Some 3600900yd^3 of material are being dredged to provide a 20000ft channel leading to an anchorage basin and deep-water berthing area. There will also be a 2494ft-long main marginal wharf, which will simultaneously accommodate four ships along the shore, a small-craft wharf, a free-standing pier and a small-boat harbour. D. W. P.

QUEENSLAND OVERSEA COMMITTEE

Rhodesian transmission system

On the 4th March 1959 a meeting was held at Brisbane for the purpose of hearing a talk by Mr. F. C. Winfield, who was on a business visit to Queensland.

The meeting was very well attended, with an almost capacity audience of approximately 60. There was considerable representation from the Queensland regional electricity boards, which at that time were holding a series of meetings in Brisbane. Also, it was pleasing to note the presence of an appreciable number of senior students from the Faculty of Engineering of the University of Queensland.

Mr. Winfield gave a résumé of the paper entitled 'The design of the 330kV transmission system for Rhodesia'. (An article based on this paper appeared in the September 1958 *Journal*, p. 485.)

The lecture was followed by a good discussion during which a wide range of questions was asked. The meeting concluded with a vote of thanks proposed by Mr. T. Priestley. W. I. G.

UNITED STATES OF AMERICA

Honorary Secretary's report

The 1959 Winter General Meeting of the American Institute of Electrical Engineers, at which the 75th anniversary of the Institute was celebrated, as well as the 1959 Institute of Radio Engineers National Convention, are now matters of history.

The various technical sessions of the A.I.E.E. General Meeting were held in New York at the Hotel Statler, Hotel Sheraton-McAlpin and the Governor Clinton, all just one block removed from each other. There were 6545 registrants, which is the largest ever and represents an increase of about 21% over last year. The current President of the A.I.E.E., Mr. L. F. Hickernell, who presided at the general session, is also an Associate Member of The Institution. The principal address at this session was by Mr. J. R. Killian, Chairman of the Corporation of Massachusetts Institute of Technology and Chairman of the President's Science Advisory Committee.

The technical sessions of the I.R.E. Convention took place at the Waldorf-Astoria Hotel and the New York Coliseum, while the Radio Engineering Show, which comprises part of the National Convention, completely filled the four exhibition floors of the Coliseum. An evening symposium which discussed 'Future developments in space' was contributed to by ten of the nation's foremost experts. The total, record-breaking, attendance at the technical sessions and at the Radio Engineering Show was 57709.

Increasing interest in The Institution

During the Eusec Conference early last May, The Institution's Honorary Secretary again had an opportunity of greeting the Presidents and Secretaries of the three major British engineering institutions. He also served as deputy and personal representative of the President of the American Institute of Electrical Engineers, who, because of a conflict in the date of the Washington, D.C., meeting of the A.I.E.E. and that of the Eusec conference, was unable to attend all the Eusec events.

It is an indication of an increasing interest in The Institution in the United States that the Honorary Secretary has been more active on its behalf during the past year than at any previous time. Hardly a day passes that he does not perform some act in relation to The Institution's affairs.

It is always a pleasure to greet representatives of The Institution who come to this country and to assist them in any way which will make their visit to the U.S.A. more enjoyable. R. H. B.

WEST AFRICAN JOINT GROUP

Annual report

The Group have had a very active year under the Chairmanship of Mr. H. Stiven, A.M.I.C.E., with Mr. J. Meade, A.M.I.E.E., continuing as Honorary Secretary.

In addition to the Annual General Meeting, which was followed by a film show, there were ten ordinary meetings and one informal talk.

The topics discussed included the introduction of Diesel traction, a history of electricity in Nigeria and the development of communication in the Cameroons. Mr. Stiven's inaugural address was entitled 'A history of the uses of bitumen'.

The Ghana and the Eastern, Northern and Western Nigeria branches continued to increase their activities under the respective Chairmanships of Mr. E. Lartey, A.M.I.C.E., Mr. F. J. Hayward, A.M.I.MECH.E., Dr. C. A. Hart, M.I.C.E., M.I.MECH.E., and Mr. T. A. MacLachlan, M.I.C.E. J. M.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th March to 16th April 1959, these members called at the Institution building and signed the Attendance Register of Oversea Members:

BENNETT, A. P. M. (Philippines)
COGLE, J. E. T. (Durban)
FRANCO, V. (Entebbe, Uganda)
GILES, P. A. (East London, Cape Province)
HALFTER, H. P. (Takoradi, Ghana)
HARMER, L. B. (Bermuda)
LINDSELL, R. A. (Gibraltar)
MARSDEN-SMEDLEY, L. (La Paz, Bolivia)
MURTY, K. R. K. (Bapatla, India)
SAGOO, H. S. (Magadi, Kenya)
TRAFFORD, W. (Singapore)
WHYTE, W. L. (Monrovia, Liberia)